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ABSTRACT

Working on the assumption that poor comprehenders of reading cannot retrieve relevant information to provide a context for the understanding of new information, a study sought to gather some empirical data about the retrieval of information. It was hoped that these data would validate some aspects of J. R. Anderson's ACT theory of memory (that elaborative processing of information should facilitate retrieval of information from long-term memory) and demonstrate certain practical and useful manipulations that should help improve student's retrieval of information. To achieve these purposes, four experimental studies of middle school students tested (1) 27 passages scaled for external links, imagery, interest, reading ease, and word frequency; (2) the role of prior knowledge in retrieval process; (3) the effects of text familiarity and cohesion on retrieval of information learned from text; and (4) methods of training seventh graders to elaborate. The results of these studies validated the theoretical point that elaborative processing of prose material enhances its later retrievability. The studies also showed that two practical ways of encouraging elaboration processing are direct teaching of elaborative processing strategies and selection of new information for which learners may have some prior related knowledge. (Appendices include complete descriptions of each study.) (HOD)

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FINAL REPORT

NIE Grant: G-78-0064

Comprehension and the
Long-Term Recall
# of Information

PI: Ellen D. Gagné

006 733

Comprehension and the Long-Term Recall of Information

NIE Grant: 6-78-0054
Project: BS-78111
PI: Ellen D. Gagné

Summary of Final Report

In recent years, due to declining achievement test scores, there has been a great deal of concern for the learning of basic skills. In the area of reading, the middle school years appear to be critical in that good and poor readers begin to distinguish themselves during this time. This suggests that comprehension is more of a problem in reading instruction than is decoding, since decoding is a major focus of elementary school reading and comprehension is the major focus in middle school.

One aspect of comprehension, which is the major focus of this project, is the retrieval of information from long-term memory. Poor comprehenders may be poor because they cannot retrieve relevant information to provide a context for the understanding of new information. Thus, it is impor-tnat to understand the nature of the retrieval process and the factors that affect the long-term recall of information. This area has not been well studied (Gagné, 1978).

The general purpose of this project was to gather some empirical data about the retrieval of information. It was hoped that these data would (1) validate some aspects of J. R. Anderson's ACT theory of memory, and (2) demonstrate certain practically useful manipulations that should help improve student's retrieval of information.

To achieve these purposes six experimental studies of middle-school students were conducted. The results of these studies validated the theoretical point that "elaborative processing" of prose material enhances its later retrievability. The studies also showed that two practical ways of encouraging elaborative processing are (1) direct teaching of elaborative processing strategies, and (2) selection of new information for which learners have some prior related knowledge.

It is hoped that by training students who have comprehension problems to elaborate on information and by giving them reading material for which they have some prior related knowledge, their comprehension will improve.

NIE Grant: 6-78-0054
Project: BS-78111
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Final Report

Comprehension and the Long-Term Recall of Information

In recent years, due to declining achievement test scores, there has been a great deal of concern for the learning of basic skills. In the area of reading, the middle school years appear to be critical in that good and poor readers begin to distinguish themselves during this time. This suggests that comprehension is more of a problem in reading instruction than is decoding, since decoding is a major focus of elementary school reading and comprehension is the major focus in middle school.

One aspect of comprehension, which is the major focus of this project, is the retrieval of information from long-term memory. Poor comprehenders may be poor because they cannot retrieve relevant information to provide a context for the understanding of new information. Thus, it is important to understand the nature of the retrieval process and the factors that affect the long-term recall of information. This area has not been well studied (Gagné, 1978).

Thus, the general purpose of this project was to gather some empirical data about the long-term recall of information. It was hoped that these data would (1) validate some aspects of J. R. Anderson's ACT theory of memory, and (2) demonstrate certain practically useful manipulations that should help improve student's long-term memory for information. In this final report, I will summarize the evidence that was gathered pertaining to each of the above-mentioned project goals. The data have been written up in articles that have been published or submitted for publication, so I will refer the reader to these articles for a more detailed description of procedures and results. All articles are attached to this report as appendices.

Validation of Anderson's ACT Theory of Memory

Anderson's ACT theory is a general theory of the architecture and basic processes of the human information processing system, one aspect of which is memory. The theory assumes that there are two basic kinds of knowledge--declarative and procedural. Declarative knowledge is knowledge that something is the case--for example, knowing that "distance equals rate times time" is declarative knowledge. Procedural knowledge is knowledge of how to do something, that is, how to perform some operation to produce a change. For example, if you answer the question "A car is travelling 35 m.p.h. How far will it travel in two hours?" with "70 miles," then you have demonstrated procedural knowledge. That is, you performed an operation (multiplication) and produced a change (70 was produced from 35 and 2). The ACT theory assumes that both kinds of knowledge are essential for competence and that they interact in ways that have not yet been specified completely. The present project focused mainly on memory for declarative knowledge.

ACT assumes that declarative knowledge is stored as a set of interconnected propositions called a "propositional network." A single proposition is the smallest unit of information that can be confirmed or denied. Propositions are interconnected through shared concepts. For example, "The dog is black" and "The dog's name is Russ" are two propositions that are interconnected through the concept of the particular dog to which reference is being made. Thus, all of our declarative knowledge is stored in a vast network of interconnected propositions.

ACT further assumes that propositions are either active or inactive. At any given time only a very small subset of propositions is in an active state. Essentially, this assumption is analogous to the distinction between short-term and long-term memory that is made in classical information processing theory (cf. Atkinson & Shiffrin, 1968). The difference is that the ACT assumptions highlight the close connection between short-term and long-term memory. In the ACT framework, the essence of long-term recall is getting the propositions one wants to recall into an active state.

How do propositions change from an inactive to an active state? This is done by "spread of activation" from propositions that are currently active to ones that are closely related in the propositional network. For example, if "The dog is black" is active, activation will quickly spread to "The dog's name is Russ" through the common concept of dog. By contrast, activation would not be likely to spread to the proposition "Iodine turns starch purple," if "The dog is black" is active because there are no common concepts shared between these two propositions.

It is postulated in Anderson's theory that elaborate processing of information should facilitate retrieval of information from long-term memory (Anderson, 1976). Elaborate processing refers to the addition of thoughts to the to-be-remembered proposition at the time the to-be-remembered proposition is being learned. For example, if the to-be-remembered proposition is "The dog's name is Russ.", elaborate processing of this proposition might include thinking "Russ is a labrador," and storing this proposition along with the to-be-remembered proposition. Elaborate processing facilitates long-term recall by providing alternate retrieval pathways. For example, if one is asked "What is the dog's name?" and one cannot directly retrieve the proposition "The dog's name is Russ." one can instead retrieve "one kind of dog is a labrador" and then "Russ is a labrador", at which point one knows that the dog's name is Russ.

This postulate has never been directly tested and, therefore, one purpose of the present project was to provide such a test. Previous work has shown that elaborative processing has an enormous effect on comprehension, (cf. Anderson & Reder, 1979) but its independent effects on retrieval processes has not been demonstrated. To demonstrate such an effect, one must control for the degree of original learning across various levels of elaborative processing. As described in the article entitled "The Role of Prior Knowledge in Retrieval Processes" (Appendix 2) we did control for the degree of original learning across levels of elaborative processing and the results showed a powerful effect of elaborative processing on retrieval, accounting for roughly 30% of the variance in one month recall of propositions. This result was replicated in a second experiment described in the same article, using less able students and a one-week retention interval.

Alternative explanations of the results were considered and the data were found wanting. Of particular interest is the alternative that information that can be stored in two ways (verbally and imaginally) is better recalled than information that is stored only verbally (Paivio, 1975). Our initial studies confounded the imageability and the elaborative processing potential of the materials. When these two factors were independently manipulated (as described in Experiment 3 of the article entitled "The Role of Prior Knowledge in Retrieval Processes") only the elaborative processing potential facilitated recall. Thus, our studies validated an hypothesis flowing from Anderson's ACT theory and also provided data that were incompatible with an alternative theory of memory, Paivio's dual-encoding theory.

Manipulations that Should Help Improve Students Long-Term Memory for Information

My initial studies supported the ACT model of memory against alternatives. The next step in the project was to ask, "given that elaborative processing is useful for long-term recall, what methods can be used to stimulate elaborative processing?" The following is a list of answers to this question that can be derived from my data:

Present information that students have some prior knowledge about.

In the studies described in the articles entitled "The Role of Prior Knowledge in Retrieval Processes" (Appendix 2) and "The Effects of Text Familiarity and Cohesion on Retrieval of Information Learned from Text" (Appendix 3) the passages that students learned varied on how familiar the topics were. The procedure for defining familiarity is described in detail in the article entitled "Twenty-Seven Passages Scaled for External Links, Imagery, Interest, Reading Ease, and Word Frequency" (Appendix 1). Essentially, familiarity was the average number of related sentences generated to the passage stimulus by a group of seventh graders who were similar to the students who participated in the other studies in the project. The correlation between passage familiarity and recall was .52. It was also the case that students reported using elaborations to cue retrieval more often for more familiar passages than for less familiar passages. (These results are reported in Experiment 1 in the article entitled "The Role of Prior Knowledge in Retrieval Processes"). Thus, it appears that familiarity (or prior knowledge) facilitates elaborative processing which in turn increases the probability that target propositions will be recalled after a month's delay.

Familiarity is More Important than Imageability

As was mentioned previously, we independently manipulated the familiarity and rated imageability of passages (Experiment 3 in the article entitled "The Role of Prior Knowledge in Retrieval Processes".) The results for one-week recall of passage propositions showed an effect for familiarity but no effect for imageability.

Familiarity May be More Important than Passage Cohesion

In the study reported in the article "The Effects of Text Familiarity and Cohesion on Retrieval of Information Learned from Text" (Appendix 3), familiarity and passage cohesion were independently varied. Cohesion was defined as the degree of repetition of concept labels across sentences in the same passage. I thought that students might be more likely to elaborately process cohesive passages because repetition of concept labels would clue the learner that the sentences were related and might cause them to elaborate on the relationships. The data, while showing the effect of familiarity on delayed recall that had been previously found, showed no effect of cohesion as I defined it. In fact, the means showed greater recall from the less cohesive passages, suggesting that well-motivated students elaborately process passages that are not particularly cohesive in an attempt to make them cohere.

Therefore, although the data suggest that cohesion is not important for delayed recall, I suspect that a better definition of cohesion might produce different results. For example, two consecutive sentences that repeat a concept label but leave some information implicit may stimulate learners to derive the implicit information (and hence to elaborately process).

Self-Generated Elaborations Appear to be Better for Long-Term Recall than Textbook-Stimulated Elaborations

In the study reported in the article entitled "Training Seventh Graders to Elaborate" (Appendix 4) we trained some seventh graders in elaborative processing and then directed them to elaborate on a list of 15 countries and to a passage about Superman. A control group received questions that stimulated the production of elaborations (for example, "What would have happened if Superman had been found by crooks instead of by the Kents?"). The group that had been trained to elaborately process recalled more countries after three days and more propositions from the Superman passage after one day than did the control group. This result suggests that it may be better to train students to elaborate on new information than simply to ask questions that stimulate the production of elaborations. Self-generated elaborations are more likely to be accessible to students than elaborations stimulated by materials or teachers.

Training Students to Elaborate Transfers to New Situations

In the study reported in the article entitled "Training Seventh Graders to Elaborate", the students in the training group recalled more propositions from a transfer passage and gave more retrospective reports of using elaborative processing than did a control group that practiced elaborating but was unaware of the purpose of elaborative processing. These results suggest that it is possible to train students to elaborately process information and that the strategy transfers to new situations.

In summary, some important activities that a teacher can do to enhance the long-term retrieval potential of information are (1) teach information for which learners have some prior related knowledge, and (2) teach students when, why, and how to elaborate on new information.

Conclusions

The theoretical point that was validated by this project was that elaborative processing of prose material enhances its later retrievability. Two practical ways of encouraging elaborative processing that were validated were (1) direct teaching of elaborative processing strategies, and (2) selection of new information for which learners have some prior related knowledge.

It is hoped that by training students who have comprehension problems to elaborate on information and by giving them reading material for which they have some prior related knowledge, their comprehension will improve.

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APPENDIX 1

Twenty-seven Passages Scaled for Linkage, Imagery, Interest, Reading Ease and Word Frequency

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Running head: Passage Attributes

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Abstract

For twenty-seven passages, scores were obtained on five dimensions related to comprehension: familiarity (linkage), imagery, interest, reading ease, and word frequency.

To obtain the familiarity (linkage score), 183 middle school children, average and above average in reading achievement, were given two minutes per sentence to generate sentences linking substance words in the passages to some idea not in the passage (i.e. from prior knowledge). The average number of such sentences generated for each passage constituted the linkage measure for that passage. The passage linkage values ranged from 5.14 to 29.95, with a mean of 16.70.

To obtain the imagery and interest scores, 62 middle school children, average and above average in reading achievement, rated the 27 passages on imagery and interest. The imagery score consisted of the average number of naturally occurring images reported after reading the passage and average level of rated interest. Passage values for imagery ranged from .92 to 5.08, with a mean of 2.57. The range of interest ratings were 1.60 to 4.08, with a mean of 2.80. In addition, reading-ease scores and work frequency were computed for each passage. The interest score consisted of the average value given on a five point rating scale of interest after reading the passages.

Correlations between each pair of passage dimensions were computed. Significant correlations included high correlations (>.80) between imagery, interest, and linkage variables, lower correlations (>.60) between these three variables and reading ease, and even lower correlations (>.40) of word frequency with all other variables except imagery. Tables present scores for linkage, imagery, interest, reading ease, and word frequency for each passage. The scaled values for all variables, except interest, are at the interval scale of measurement, making the materials useful for studies in which quantitative hypotheses are being tested.

Twenty-Seven Passages Scaled for Linkage, Imagery, Interest, Reading Ease, and Word Frequency

There is a great deal of norming data available on the attributes of words (cf. Paivio, Yuille, & Madigan, 1968; Togglia & Battig, 1978), and many of these attributes have been shown to be related to recall (cf. Berrian, Metzler, Kroll, & Clark-Meyers, 1979; Paivio, Yuille & Rogers, 1969; Noble, 1963; Underwood, 1969) or ease of learning (cf. van der Veur, 1975). By contrast, norming data on passages is hard to find. A few studies have obtained norms for a particular purpose on one or two specific passages (cf. Montague & Carter, 1973; Johnson, 1973). Miller and Coleman (1967) obtained complexity norms for 36 passages. Other than this work, we are unaware of any norms available for a set of passages. It would seem to be important to obtain norms for passages as part of the attempt to develop theories of discourse processing.

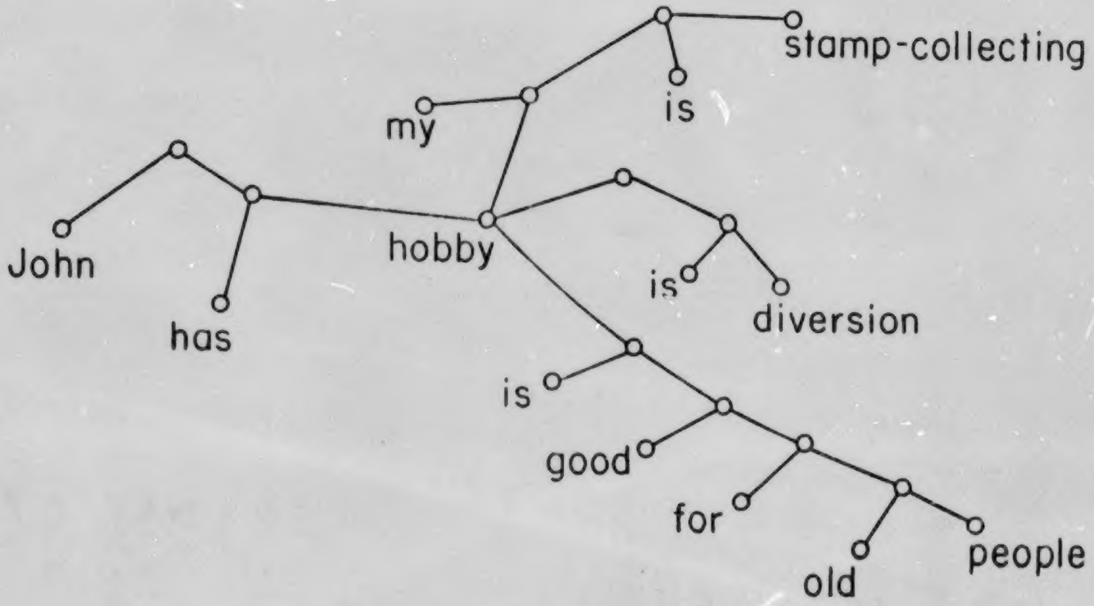
The following set of experiments was designed to fill this gap. The corpus of materials on which norming information was gathered was 27 one-paragraph passages. These passages, along with identifying numbers, are presented in Appendix A. One-third of these passages each were factual, conceptual, and narrative in form. Nine passage sets (three within each passage form) were matched on syntax while they were written to vary widely on the norming dimensions.

Experiment 1

The norming dimension in this experiment was linkage (L). Linkage is a passage level analog to Noble's (1952) meaningfulness measure for words. A linkage score for a passage is the average number of sentences subjects generate connecting a substance word in a passage sentence to ideas not stated in the passage. The measure is theoretically compatible with propositional theories of meaning (cf. Anderson, 1980; Kintsch, 1974) in that the meaning of a given idea is thought to be comprised of all propositions related to that idea in long term memory. For example, Figure 1 shows all the propositions related to the node hobby in a hypothetical person's memory. Thus, the linkage measure provides a quantitative index of propositional meaningfulness.

There is ample evidence to suggest that linkage should be an important factor in ease of learning, comprehension, and/or recall. The work of John Bransford and his colleagues (Bransford & Johnson, 1972; Stein, Morris, & Bransford, 1978) demonstrates in a qualitative manner the enormous importance of prior knowledge in comprehension. Ausubel showed the influence of prior knowledge on comprehension long before others (Ausubel, Robbins, & Blake, 1957; Ausubel, Stager, & Gaite, 1968). However, the emphasis of past work has been qualitative. The norming data collected in this experiment results in a quantitative measure of prior knowledge and hence lends itself to the study of quantitative hypotheses.

Figure I


stamp-collecting
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Method

Subjects. Subjects were 183 7th and 8th graders who were average or above average on the Gates-McGuinitie Reading Achievement grade norms. Their average grade level score was 7th grade, 7th month. The subjects were from an upper middle-class suburb of Atlanta, Georgia.

The subjects participated in the study during school hours. Their teachers were paid to assist in insuring high motivation among the students. An average of 20 subjects generated linkages for each passage (range = 14 - 25).

Passages. The passages were either five or six sentences long. There were 9 narrative (N) passages, 9 factual (F) passages, and 9 conceptual (C) passages reported in this article. Narrative passages described a person and some actions in a story-telling manner. Factual passages described a particular person, place, or event (some fictional and some non-fictional), and were written to simulate non-fictional history, biography, or geography texts. Conceptual passages defined and described a class of objects or relationships in a manner similar to science or social science texts or technical writing within the humanities.

The nine passages within each passage form were comprised of three sets of three matched passages. Within each set, syntax was constant. (See table 1 for a sample set.)

Linkages. A linkage was defined as any sentence that a subject wrote down connecting a substantive idea in the passage with prior knowledge. For example, if a passage sentence was "German chocolate cakes are a joy to mankind," responses such as "I like cakes" or "Hitler was German" are linkages.

The procedure for obtaining linkages was the following: Subjects, during a regular language arts class, were handed booklets that contained instructions and six passages--one practice passage, and five to-be-normed passages (balanced for passage type and set across subjects). Each passage was presented on a single page followed by six pages each containing one of the sentences from the passage typed 10 times at even intervals down an entire 8" x 12" page.

The subjects were directed to write down as many sentences as they could that connected substance words in the text sentence to something they already knew. They were shown several examples and non-examples of acceptable linkages for a sample sentence. Then they generated linkages to a practice passage and were given feedback on this.

Following instructions and feedback, Ss responded to two to-be-normed passages one day and to three more on another day that same week. They read each passage and then responded to each separate sentence for two minutes each.

Linkage scores. The scoring system for linkages was guided by our notion of what linkages would provide useful retrieval pathways

Table 1

Sample Set of Passages Varying in Linkage while Maintaining Constant Syntax

High Linkage: Henry James

Henry James wrote historical novels.
Many novels described states of mind produced by human actions.
The setting was often in northern England.
Portrait is one of James' novels.
It discusses the states of mind produced by human actions.
The main character in the novel is an American woman in old Europe.

Medium Linkage: Thomas Gray

Thomas Gray created eloquent verse.
Many verses enumerated truisms of the Divine romanticized with meditative bliss.
The philosophy was often of heartfelt action.
"Elegy" is typical of Gray's verse.
It presents truisms of the Divine romanticized with meditative bliss.
The subject matter in the verse is the universal dignity in common mortality.

Low Linkage: Wolfram von Eschenbach

Wolfram von Eschenbach composed Homeric Epics.
Many epics elucidated the quest for the Grail concomitant with quotidian chivalry.
The schemata was often from Wartburgian annals.
Parzival is exemplary of Eschenbach's epics.
It delineates the quest for the Grail concomitant with quotidian chivalry.
The trenchant protagonist in the epic is a guileless novitiate in consecrated indenture.

to the propositions in the passages. According to the notion of spreading activation (cf. Anderson, 1976), activation goes from the nodes activated by the cue down all pathways connected to these nodes. The strength of activation down each pathway is divided among all the pathways. Therefore, if there are many pathways connected to the activated nodes, the probability of retrieval will be relatively low. In other terms, this effect is called interference. We judged that very common words such as function words, the verbs to be and to have, and several common adverbs and adjectives occur so frequently that there would be much interference in attempting to use them as retrieval cues. Therefore, no linkage was counted if subjects generated sentences in which the common link to the passage sentence was (1) the verb to be, (2) the verb to have, (3) a preposition, (4) a conjunction, (5) an article, (6) a frequently occurring adjective (most, some, every, all, many, numerous, regular), or (7) a frequently occurring adverb (very, quite, finally). In addition, within syntactically equivalent sets, if a linkage was not counted in one passage, for the above given reasons, then linkages to the analogous words in other passages in the set were also not counted. This included such words as quiet, abundant, myriad, multifarious, considerably, and exorbitantly. Thus, the number of words for which links could potentially be generated remained constant within sets.

Four scorers scored the response sheets for number of linkages generated. On a random sample of ten subjects, interscorer reliability was .98 using the intraclass formula (Guilford, 1954).

Results

Reliability. The Spearman-Brown reliability of linkage measures across subjects (n = 14) was .93. This indicates that the linkage measure is quite reliable.

Linkage. Passage linkage values ranged from 5.14 to 29.95 with an average of 16.70. The average linkage value for each passage is shown in Table 2, along with other passage attribute data gathered in Experiment 2. Passages were entered into this table in order of their linkage values, with Passage 1 having the highest linkages value and Passage 27 having the lowest linkage values. Passages 1 through 27 are given in their entirety in Appendix A.

The means and standard deviations for linkage as a function of passage form (factual, conceptual, or narrative) and passage set (three sets within each passage form were equated for syntax while varying widely on linkage) are shown in Tables 3 and 4, respectively. In addition, data gathered in Experiment 2 are shown in these tables. Analyses of variance revealed no differences in linkage as a function of passage form or passage set. Thus, the role of linkage can be studied independent of passage form and syntax within this set of passages.

Table 2

Passage Ratings for Linkage, Interest, Imagery, Word Frequency, and Reading Ease

Passage Identification Number	[a]Type	[b]Set	Linkage n (s.d.) M	Interest n (s.d.) M	Imagery n (s.d.) M	Word Frequency n (s.d.) M	Reading Ease Score
1	N	8	21 (11.00) 29.95	22 (1.02) 4.00	25 (1.68) 5.00	37 (100.11) 88.70	73
2	C	4	21 (12.74) 28.67	25 (1.24) 3.12	23 (1.86) 3.48	24 (234.98) 124.75	83
3	F	3	21 (11.31) 28.29	25 (1.24) 2.88	24 (2.31) 4.13	25 (58.51) 53.56	49
4	N	7	23 (9.75) 26.39	23 (.95) 4.08	25 (1.93) 5.08	30 (259.16) 223.20	79
5	C	6	16 (09.34) 24.19	25 (1.26) 2.80	23 (1.79) 2.93	32 (147.06) 128.75	87
6	N	9	24 (11.31) 23.83	23 (1.31) 3.22	25 (1.74) 4.28	27 (159.55) 85.67	92

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[a] Passage Type: N = Narrative, C = Conceptual, F = Factual

[b] Sets 1-3 are 3 sets of Factual passages matched for syntax but varying widely on Linkage, 4-6 are 3 sets of Conceptual passages matched for syntax but varying widely on Linkage, 7-9 are 3 sets of Narrative passages matched for syntax but varying widely on Linkage.

[c] n for Word Frequency is the number of words over which an average frequency is computed. The n for all other measures is the number of subjects who gave a rating on that passage.

Table 2 (continued)

Passage	aType	bSet	Linkage n (s.d.) M	Interest n (s.d.) M	Imagery n (s.d.) M	Word Frequency n (s.d.) M	Reading Ease Score
7	C	5	21 (9.35) 23.71	25 (.93) 3.96	23 (1.60) 3.02	40 (617.08) 241.50	73
8	F	2	16 (8.44) 23.63	25 (.88) 3.24	24 (1.08) 1.77	32 (557.08) 294.94	65
9	C	6	20 (8.14) 23.55	25 (1.08) 3.52	23 (2.08) 3.61	32 (119.53) 86.72	62
10	F	1	20 (7.63) 21.85	25 (1.24) 2.96	24 (1.64) 3.58	28 (353.29) 232.50	45
11	N	9	21 (9.22) 21.05	24 (1.25) 3.50	24 (2.03) 3.29	27 (77.57) 25.48	55
12	F	1	22 (7.36) 17.23	23 (1.29) 2.87	25 (1.37) 2.28	28 (263.76) 82.75	28
13	F	2	16 (9.10) 17.06	24 (1.07) 2.25	24 (1.68) 1.70	32 (81.00) 56.69	32
14	C	5	22 (7.54) 16.73	24 (1.30) 2.96	24 (1.43) 1.83	40 (597.70) 241.60	52
15	N	7	14 (6.99) 15.79	24 (1.33) 2.96	24 (2.01) 3.13	30 (242.20) 81.10	58
16	C	4	23 (6.39) 15.78	25 (1.03) 2.84	24 (1.56) 2.50	24 (40.99) 13.17	61
17	N	8	22 (4.49) 15.64	25 (1.04) 2.44	24 (2.46) 2.17	37 (72.05) 28.76	33

Table 2 (continued)

Passage	aType	bSet	Linkage n (s.d.) M	Interest n (s.d.) M	Imagery n (s.d.) M	Word Frequency n (s.d.) M	Reading Ease Score
18	F	3	23 (6.26) 10.96	23 (1.04) 3.00	24 (1.35 2.46	25 (21.56) 7.44	3
19	N	8	17 (5.81) 10.41	25 (.96) 1.60	23 (1.31) 1.22	37 (3.04) 3.24	22
20	F	3	19 (6.25) 10.32	23 (1.19) 2.35	25 (1.75) 2.16	25 (21.73) 8.00	33
21	F	1	20 (5.52) 8.30	23 (1.14) 2.13	25 (1.98) 1.48	28 (55.85) 28.71	35
22	N	9	18 (7.36) 8.28	25 (1.22) 2.40	23 (1.37) 1.61	27 (1.08) .93	61
23	F	2	22 (4.99) 6.32	23 (1.17) 2.00	24 (1.10) .92	32 (9.22) 5.75	19
24	C	6	25 (6.09) 6.24	23 (1.23) 2.17	24 (1.52) 1.29	32 (4.82) 2.34	14
25	C	4	18 (3.36) 6.17	23 (1.31) 2.09	24 (1.29) 1.00	24 (11.42) 5.21	26
26	C	5	23 (2.90) 5.39	23 (1.18) 1.87	24 (2.18) 1.63	40 (577.62) 135.75	-3
27	N	7	21 (4.83) 5.14	25 (1.39) 2.44	22 (1.85) 1.91	30 (39.61) 8.6	35

Table 3

Mean Values of Five Passage Attributes as Function of Passage Form[a]
(s.d. in parentheses)

Passage Form	L	INT	IMA	WF	RE
	(8.98)	(.69)	(.96)	(92.41)	(31.49)
C	16.71	2.81	2.37	108.87	50.56
	(7.56)	(.45)	(1.02)	(105.43)	(17.80)
N	16.00	2.63	2.28	85.59	34.33
	(8.52)	(.82)	(1.46)	(70.78)	(23.10)
F	17.39	2.96	3.08	60.63	56.44
	(8.06)	(.66)	(1.18)	(89.42)	(25.64)
Total	16.70	2.80	2.57	85.03	47.11

L = Linkage; INT = Interest; IMA = Imagery; WF = Word Frequency;
RE = Reading Ease

[a] Nine passages contribute to each cell mean. Twenty-seven passages contribute to each total mean.

Table 4

Mean Values for the Five Passage Attributes as Function of Passage Set[a] (s.d. in parentheses)

Passage Set	L	INT	IMA	WF	RE
1	(6.89) 15.79	(.46) 2.65	(1.06) 2.45	(105.57) 114.65	(8.54) 36.00
2	(8.74) 15.67	(.66) 2.50	(.47) 1.46	(154.37) 111.13	(23.71) 38.67
3	(10.20) 16.52	(.35) 2.74	(1.06) 2.92	(26.47) 23.00	(23.36) 28.33
4	(11.29) 16.87	(.53) 2.68	(1.25) 2.33	(66.84) 47.71	(28.75) 56.67
5	(9.25) 15.28	(1.05) 2.93	(.75) 2.16	(61.08) 206.28	(39.25) 40.67
6	(10.18) 17.99	(.68) 2.83	(1.19) 2.61	(64.38) 72.60	(37.10) 54.33
7	(10.63) 15.77	(.84) 3.16	(1.60) 3.37	(109.16) 104.30	(22.01) 57.33
8	(10.12) 18.67	(1.22) 2.68	(1.97) 2.80	(43.87) 40.23	(26.84) 42.67
9	(8.29) 17.72	(.57) 3.04	(1.35) 3.06	(43.60) 37.36	(19.86) 69.33

L = Linkage; INT = Interest; IMA = Imagery; WF = Word Frequency; RE = Reading Ease.

[a] Three passages contribute to each cell mean.

Experiment 2

The norming dimensions in this experiment were imagery (IMA) and interest (INT). The use of imagery strategies has been related to the recall of discourse (Anderson & Kulhavy, 1972), a passage's vividness has been related to its recall (Montague & Carter, 1973), and the imagery value of words has been related to their recall (Paivio, Yuille, & Rogers, 1969). Thus, it is quite probable that a passage's imagery value is related to its recall; however, this hypothesis has not been directly tested. The present experiment provides norming information that will allow for a direct test of this hypothesis.

The role of interest in comprehension and retrieval of information is important to study since there is a pedagogical truism that high interest material is easier to learn and better retained. However, we found no data on this point.

In addition to imagery and interest, each passage was scored for reading ease (Flesch, 1951) and average word frequency. Reading ease scores are easy to compute and are available for many school texts. Thus, it is of practical importance to relate the effects of the more theoretically important variables (linkage, imagery, and interest) to this readily available measure. That is, if one or more of the theoretically important variables is shown to influence comprehension, and is also shown to be highly related to reading ease, then reading ease can serve as an estimate of the underlying variable(s) in everyday situations.

Average word frequency was computed because it is important to attend to the competing hypothesis that the obtained effects are due to the greater output availability of words that occur more frequently. If one assumes that output availability is a function of practice, then the frequency of occurrence of a word is probably a good measure of its output availability. It was anticipated that word frequency would correlate with the other variables but we wanted to know the extent of the correlation.

Method

Subjects. The 62 7th and 8th grade subjects were from a university community in Georgia. They were average and above average on the California Test of Basic Skills reading test grade level scores (national norms). Their mean grade level score was 11th grade, 3 months. Subjects participated in this study after school hours and were paid $2.00/hour.

Procedure. The interest and imagery measures were administered to subjects in the following manner: Each subject rated 18 passages for interest and 18 different passages for imagery, with half of the subjects responding to interest first. (Some of the passages rated are not reported here.) Passage order was randomized for each subject, and subjects worked through the ratings at their own speed.

Interest rating. Subjects were asked to indicate how interesting each of the passages was. The interest of each passage was rated on the following form:

very boring	a little boring	neutral	a little interesting	very interesting

An average of 24 subjects rated each passage.

Imagery rating. Subjects were instructed to indicate how many images came to mind when they read each passage. They were asked not to try to generate images, but only report the number of images that naturally occurred. The imagery rating was of the following form:

HOW MANY DIFFERENT IMAGES DID THIS PASSAGE MAKE YOU THINK OF?

none ______ three ______

one ______ four ______

two ______ more than four ______ If so, how many ______

This form was used in favor of a rating scale because we thought this more specific question might provide a more reliable estimate of passage imageability than would a general ranking. An average of 24 subjects rated each passage.

Reading ease. Flesch's (1951) reading ease score was calculated for each passage. This measure is based on the average number of syllables per word and the average number of words per sentence. A score of 100 signifies a passage that is very easy to read, whereas a score of 0 signifies an extremely difficult passage.

Word frequency. A word frequency measure was computed based on the corpus vocabulary in Kuçera and Francis (1967). The frequency reported for each word used in the linkage measure was summed across words within each passage, and the total frequency was divided by the total number of substance words. This measure is, therefore, an average frequency per substance word.

Results

Reliability. The Spearman-Brown estimate of reliability of imagery ratings across Ss (n = 22) was .90. The Spearman-Brown estimate of reliability of interest ratings across Ss (n = 22) was .87. Thus, both measures appear to be highly reliable.

Passage ratings. The range of imagery ratings for passages was .92 to 5.08 with a mean of 2.57. The range of interest ratings for passages was 1.60 to 4.08, with a mean of 2.80.

The means and standard deviations for each passage on each of the four variables (interest, imagery, word frequency, and reading ease) are shown in Table 2, along with the linkage value from Experiment 1.

Table 3 shows the means and standard deviations on each variable across all passages. Table 3 also shows the means and standard deviations on INT, IMA, and WF, and the RE score as a function of passage form and Table 4 shows the means and standard deviations for the variables as a function of passage set. ANOVA's for each measure revealed no significant differences due to passage form or passage set. Thus, the role of each of these variables can be studied independent of passage form or syntactical structure.

Intercorrelations. Table 5 shows correlations between the linkage, interest, imagery, word frequency, and reading ease values. These correlations were computed using the mean rating (L, INT, IMA) or the computed score (WF and RE) for each passage. Each correlation, therefore, has an N of 27. With one exception (word frequency with imagery), the correlations were significant, with $p < .01$.

There are high correlations between the imagery, interest and linkage variables, somewhat lower correlations between these three variables and reading ease, and even lower, but still substantial, correlations of word frequency with all the other variables.

These significant correlations suggest that it will be difficult to isolate the effect of any one variable from the effects of others. Consequently, the following strategy should be pursued if the intent is to isolate the effects of one passage attribute: Select non-typical passages that are high on the attribute of interest and low on other attributes. For example, the Henry James passage (number 8) has a relatively high linkage value (23.63) and low imagery value (1.77) while the Carol passage (number 6) has an equally high linkage value (23.83) and a high imagery value (4.28). The role of imagery could thus be assessed independent of linkage for these two passages.

One advantage of these materials is that the degree of correlation of linkage, interest, imagery, reading ease, and word frequency is made explicit. Often, in studies of word recall, when differences due to one variable have been studied, the correlation with other attributes has not been discussed.

General Discussion

Twenty-seven passages scaled for linkage, interest, imagery, reading ease, and word frequency have been described. These passages vary as to form (conceptual, narrative, and factual) so that sampling from them should allow researchers to generalize their results across passages (Clark, 1973). Within this group of 27 passages, there are

Table 5
Intercorrelations of the Five Passage Attributes

	L	INT	IMA	WF	RE
L		.81***	.83***	.56**	.78***
INT			.83***	.55**	.71***
IMA				.35	.68***
WF					.45*

L = Linkage; INR = Interest; IMA = Imagery; WF = Word Frequency; RE = Reading Ease

*p < .01

**p < .005

***p < .001

sets of passages that vary widely on the scaled values yet maintain a constant syntax so that the passages may be used to vary the scaled variables while holding syntax constant. The scaled values for all the variables except interest are at an interval level of measurement, thus making the materials useful for studies in which quantitative hypotheses are being tested.

These materials should prove useful for a variety of questions related to the role of linkage, imagery, interest, reading ease, and word frequency in various processes. They should be particularly useful when quantitative as well as qualitative information is desired, when the goal is to generalize a finding across passage types, or when there is an interest in relating one's results to theories of propositional memory.

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Appendix A
Rated Passages and their Identification Numbers

1

The runners stretched their relaxed muscles with rhythmic motions. Susan watched the officials on the field while thinking of her plan. She massaged her muscles while walking to the starting line. When the gun sounded, the runners took off. Susan enjoyed the feeling of her body in motion. At the starting line, her children shouted encouragement to her.

2

Pressure produces sound. The piano has keys connected to a base. The hammers are made of wood. When pressure is put on a key, motion moves from the finger to the key. Then the motion flows to the hammer. Finally, the strings vibrate and sound is produced.

3

Governor Smith has many dogs. Smith's father was a bakery storekeeper. Governor Smith has eight sisters. Stamp-collecting is a special hobby for Governor Smith. Smith visits his sisters every Christmas. Smith's favorite sister likes jewelry very much.

4

The principal had found the money under a desk. The key has been placed under a book. But everything depended on finding the key after school. When school was over, Nancy went back to the lockers and found the hidden key under a book. Unaware of the open door, she walked past the principal. It appeared that the money was lost.

5

AA quality eggs are the best. Eggs that have much thick white often display a hard shell. Eggs that have a firm yolk often have some thin white. AA quality eggs cover a small area. They have much thick white around the yolk and also have some thin white. In AA quality eggs, the yolk is firm.

6

Carol gazed at the notebook and the chalk. The homework had not been copied. The teacher told her to write with great care. Carol looked at the notebook nervously. Then she copied the homework with the chalk. She stood back to permit her teacher to gaze upon what she wrote.

7

German chocolate cakes are a joy to mankind! Cakes that are made with German cocoas often have a rich taste. The light texture of chocolate cakes is often produced by the number of eggs. German chocolate cakes are delicacies containing pieces of one or more of the German cocoas mixed with whipped cream. In their rich taste and light texture they are much like other chocolate cakes.

8

Henry James wrote historical novels. Many novels described states of mind produced by human actions. The setting was often in northern England. Portrait is one of James' novels. It discusses the states of mind produced by human actions. The main character in the novel is an American woman in old Europe.

9

Show quality goldfish are superior. Goldfish that have numerous regular scales often display short fins. Goldfish that have an oval body often have some ornate scales. Show quality goldfish display a flowing tail. They have many regular scales on the head and also have some ornate scales. In show quality goldfish, the body is oval.

10

Washington, D.C. is a city of two million people. Many marching bands are started in private colleges. Some soccer teams are formed by factory workers. Washington, D.C. is a city made of small neighborhoods. There are many factories in Washington, D.C. Washington, D.C. has many marching bands and soccer teams.

11

Eric contemplated the forceps and the scalpel. The cornea had not been detached. The opthalmologist called him to perform with the utmost caution. Eric selected the forceps tensely. Then he detached the cornea with the scalpel. He side-stepped to allow the opthalmologist to contemplate how he performed.

12

Stockholm is a metropolis of two hundred thousand citizens. Numerous wind ensembles are introduced in theological seminaries. Some polo factions are created by agency employees. Stockholm is a metropolis composed of undersized precincts. There are numerous agencies in Stockholm. Stockholm has numerous wind ensembles and polo factions.

13

Thomas Gray created eloquent verse. Many verses enumerated truisms of the Divine romanticized with meditative bliss. The philosophy was often of heartfelt action. "Elegy" is typical of Gray's verse. It presents truisms of the Divine romanticized with meditative bliss. The subject matter in the verse is the universal dignity in common mortality.

14

Zinc aluminum alloys are useful to mankind. Alloys that are made with aluminum materials often have a light weight. The great strength of aluminum alloys is often produced by the amount of iron. Zinc aluminum alloys are metals containing parts of one or more of the aluminum materials merged with purified zinc. In their light weight and great strength they are similar to other aluminum alloys.

15

The marauder had hid the sextant under the astrolabe. The lanyards had been deposited under the gib. But everything depended on securing the lanyards after the storm. When the storm was over, Sigunde returned to the forecastle and found the discarded lanyards under the gib. Unaware of the foreboding clouds, she crept past the marauder. It appeared that the sextant was missing.

16

Torches engender blazes. Fires consist of tinder encompassed by bark. The kindling contacts the embers. When a torch is extended to tinder, combustion is transferred from the taper to the tinder. Then combustion migrates to the kindling. Finally the peat ignites and a blaze is engendered.

17

The model readied the stiff gesso for faultless pigmentation. Raoul summoned the inspiration from his palette while projecting the conformations. He contemplated his canvas while anticipating the initial strokes. When the illumination stabilized, the model disrobed. Raoul appraised the form on his canvas without pigmentation. After the initial strokes, his conformations created substance for him.

18

Emperor Hollingshead has abundant Weimaraners. Hollingshead's sire was a traveling cooper. Emperor Hollingshead has eight siblings. Racquetball is a noteworthy avocation for Emperor Hollingshead. Hollingshead frequents his siblings every Ramadan. Hollingshead's most esteemed sibling appreciates sonnets considerably.

19

The peers recounted the unctious bravado of the perilous utterance. Francois affronted the entourage with his mellifluence while assuaging the advocate. He obfuscated his bravado before precipitating the ensuing respite. When the adjudicator commenced, the peers heeded. Francois undermined his arraigment on sedition for the utterance. During the ensuing respite, his benefactor solicited succor for him.

20

Premier Chang maintains multiferious Salukis. Chang's progenitor was a dram sutler. Premier Chang possesses eight kinsmen. Jousting is a cossetted diversion for Premier Chang. Chang sojourns to his kinsmen every Venu. Chang's most esteemed kinsman approbates victuals exorbitantly.

21

Accra is a cosmopolis of six hundred thousand denizens. A myriad of motet societies are instituted by secular coteries. Some quoit squads are forged by corporation toilers. Accra is a cosmpoplis constituted of miniscule alentours. There are a myriad of corporations in Accra. Accra has a myriad of motet societies and quoit squads.

22

Leatha scrutinized the jute and the crampons. The valve had not been disengaged. The docent bade her plummet down the craggy precipice. Leatha manipulated the jute timorously. Then she disengaged the valve with the crampons. She vaulted to coerce the docent to scrutinize how she plummeted.

23

Wolfram von Eschenbach composed Homeric Epics. Many epics elucidated the quest for the Grail concomitant with quotidian chivalry. The schemata was often from Wartburgian annals. Parzival is exemplary of Eschenbach's epics. It delineates the quest for the Grail concomitant with quotidian chivalry. The trenchant protagonist in the epic is a guileless novitiate in consecrated indenture.

24

Cum laude theses are meritorious. Theses that have multifarious inimitible citations often evince obscure allusions. Theses that have cogent essence often have some canonical citations. Cum laude theses evince an ingenious hypothesis. They have multifarious iminitible citations in the bibliographies and also have some canonical citations. In cum laude theses, the essence is cogent.

25

Alphons increment quanta. The microcosm possesses an integument superimposed on an entity. The focus consists of neutrinos. When alphons fusilade the integument quanta are permeated from the conveyance to the integument. Then the quanta peregrinates to the focus. Ultimately, the quark is infiltrated and quanta are incremented.

26

Organic halogen amalgamations are ubiquitous in biospheres. Conjugates that conjoin halogen constituents frequently have substantive attributes. The chemical propagations of organic amalgamations are often ascertained by the aggregate of bits. Organic halogen amalgamations are conjugates conjoining substructures of one or more of the halogen constituents bonded to carbon monads. In their substantive attributes and chemical propagations they are analogous to other organic amalgamations.

27

The oracle had conjured the icon from under the ginkgo. The cithara has been reposited under the linden. But everything culminated in relinquishing the cithara after vespers. When vespers had transpired, Babanam reconnoitered at the Pagoda and retrieved the sacrosanct cithara from under the linden. Oblivious to the festooned vestibule, she slunk past the oracle. It eventuated that the icon was purloined.

APPENDIX 2

The Role of Prior Knowledge in Retrieval Processes: An Elaborative Processing Account

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Running head: Prior Knowledge and Retrieval

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Abstract

Three experiments were done with middle school students. In Experiments 1 and 2, students learned to an 85% correct criterion brief passages that varied on the amount of prior related knowledge they stimulated. After a delay of one or four weeks, students free recalled the passages. With amount of rehearsal controlled, recall of information from passages with high prior related knowledge was significantly greater than from passages with medium or low prior related knowledge. Twenty-eight percent of the variation in delayed recall was explained by prior related knowledge.

In Experiment 3, students learned to criterion two passages that varied on either prior related knowledge or imagery but not both. Only passages that varied on prior related knowledge showed differential delayed recall. The results of all three experiments are explained as being due to a more elaborate encoding of high prior related knowledge passages. The elaborate encoding provides alternate retrieval paths and clues for reconstruction. The educational implications of these results include a new question about mastery learning.

The Role of Prior Knowledge in Retrieval Processes: An Elaborative Processing Account

Retrieval processes--including both activation and reconstruction of knowledge--are important components of problem-solving (Maier, 1930), inductive reasoning (Bruner, Goodnow, & Austin, 1956), inference-making (Frase, 1973; Hayes-Roth & Thorndyke, 1979), and decision-making (Kahneman & Tversky, 1972). Therefore, a better understanding of retrieval processes should contribute to a better understanding of a variety of other cognitive processes. This paper reports some studies of retrieval processes.

More specifically, this paper is concerned with the effects of the reader's prior knowledge on retrieval of text information from long-term memory. Previous studies of the effects of prior knowledge on memory have found that more is recalled from a text when the reader has more prior knowledge about it (Annis & Davis, 1978-79; Chiesi, Spilich, & Voss, 1979). Such studies have traced this effect to encoding processes: readers with more prior knowledge about a topic can encode new information about that topic faster and so they learn more in a given amount of time (Johnson, 1973; Spilich, Vesonder, Chiesi, & Voss, 1979).

In contrast to these previous studies, the present studies investigate the effects of prior knowledge on retrieval processes. The effect of prior knowledge on speed of encoding is eliminated as a factor by controlling for the amount of information that is present at the start of the retention interval.

Another concern of the present paper is to evaluate the utility of a quantitative and content-free measure of prior knowledge, something that is not currently available. Our measure of prior knowledge is the number of ideas generated by subjects in response to the to-be-remembered (target) ideas. It is assumed that the number of ideas generated represents the relative amount of prior knowledge that readers are likely to bring to bear on a target passage. The fact that this measure is quantitative makes it useful in answering quantitative questions such as "how much of the variance in long-term recall can be accounted for by prior knowledge?" The fact that this measure is content-free makes it possible to compare the effects of prior knowledge across different content areas. In the present study quantitative questions are posed and passages with different content are compared.

In summary, the purposes of these studies were (1) to examine the role of prior knowledge in retrieval processes, and (2) to assess the utility of a quantitative and content-free measure of prior knowledge. The general procedure used to attain these goals was to have subjects learn to an 85% correct criterion passages that varied on prior knowledge. Immediately, one, or four weeks later subjects free recalled everything they could remember from the passages. Experiment 1 is the main study, demonstrating the beneficial effect of prior knowledge on long-term recall. Experiment 2 is a replication using less able students and a shorter retention interval. Experiment 3 independently manipulates prior knowledge and imagery to determine which causes variations in long-term recall.

Experiment 1

Subjects

Sixty-one seventh and eighth grade students of average or above average reading ability (mean grade level score = 11th grade, 3 months on the California Test of Basic Skills) participated in the study. The participants received $6 for two one-hour sessions. Seven subjects failed to reach criterion on their most difficult passage and were therefore dropped from data analysis, leaving 54 subjects.

Design

The experimental design was a 3 x 2 design, with one within-subject factor (prior knowledge--high, medium, or low) and one between-subject factor (retention interval--11 minutes or 4 weeks). Nested within this design was a Latin-square design that controlled for passage type (factual, conceptual, or narrative) and order of presentation across the three levels of prior knowledge.

Materials

Overview. The materials used were 27 passages, each five to seven sentences long. To give some idea of the variety of content in the passages, Table 1 shows the title of each. The three different types of passages (factual, conceptual, and narrative) were chosen to be representative of the domain of prose material that students encounter in school. Factual passages described a particular person, place, or event, either fictional or non-fictional, and simulated history, biography, or geography texts. Conceptual passages defined and described a class of objects or relationships in a manner similar to science or social science texts or technical writing within the humanities. Narrative passages described a person and some actions in a storytelling manner.

Insert Table 1 about here

Within each of these passage types, three sets of three passages each were written to have identical syntax and word counts but to differ on amount of prior related knowledge (high, medium, or low).

Definition of prior related knowledge. The procedures for developing prior related knowledge norms for the 27 passages are described in detail in Gagné, Bell, Yarbrough, & Weidemann (1981). The norms were established using 182 seventh and eighth grade students with average or above average reading scores on the Gates-McGuinitie Reading Achievement Test. These subjects generated as many sentences as they could that used concepts in each sentence in the passages but did not simply repeat passage information. For example, for the passage sentence, "Chocolate cakes are rich..." typical responses were "I like to eat chocolate cakes" and "Eggs make cake rich." Subjects were given two minutes to generate responses to each passage sentence. Approximately 20 students generated responses for each passage and the average number of responses formed the prior knowledge score for that passage.

Prior knowledge scores ranged from 5.14 to 29.95, with an average of 16.70 sentences generated per passage. The mean prior knowledge scores for passages representing high, medium, and low levels of prior related knowledge were 25.61, 17.09, and 7.40. Analyses of variance revealed no differences in prior knowledge as a function of passage type or passage set (i.e., syntax). A sample set of factual passages that vary on prior knowledge is shown in Table 2.

Insert Table 2 about here

As can be seen from this example, the low prior knowledge passages use much more difficult vocabulary than do the high prior knowledge passages. Thus, it may appear that our definition of prior knowledge is "just" a measure of vocabularly. However, this is not the case. Rather, it is in part a measure of vocabularly knowledge and in part a measure of other knowledge the learner has relevant to the target information. Both definitional responses (for example, "rich means made of eggs, butter, and cream") and other informational responses (for example, "chocolate mousse is richer than chocolate cake") are equally acceptable as units of prior knowledge. The question of interest is whether the amount of prior knowledge that a reader possesses affects the amount that can be recalled. Therefore, we do not make distinctions among different types of prior knowledge.

Relationship between prior knowledge and other passage attributes. As has been reported elsewhere (Gagne, et al., 1981), in addition to being normed for prior knowledge, these 27 passages were normed for rated interest (1 = low, 5 = high) and for the average number of images stimulated while reading the passage. Also, the average content word frequency for each passage was determined using the Kučera and Francis (1967) word frequency norms. Finally, a readability measure was computed using Flesch's (1951) formula, which is based on word length and number of syllables. Each of these measures was found to correlate highly with prior knowledge (the range of correlations was from .56 to .83). Table 3 shows the average value of the high, medium, and low prior knowledge passages on each of these other passage attributes.

Insert Table 3 about here

By having passages for which all of these measures were available it was possible to investigate the relative contributions of each variable to amount of long-term recall. The regression analysis relevant to this investigation are presented in the results section.

Procedure

Each subject came to a campus laboratory and learned three passages, one of each passage type and one each at the high, medium, and low prior knowledge level. (The order of learning of passages of different types and prior knowledge levels was counterbalanced across subjects, using a Latin-square design.) The steps in the procedure were: (1) prequestions, (2) familiarization, (3) learning, and (4) recall. Each of these is described in detail below.

Prequestions. Prior to learning the passages, the experimenter asked the subject a question based on each proposition in the passage about to be learned. The purpose of this procedure was twofold. First, asking the questions beforehand assured us that relatively few passage propositions (less than 1%) were known prior to the experiment. Second, it encouraged the activation of relevant prior knowledge. A typical subject would make "educated guesses" to answer the prequestion, thus showing that he or she was activating relevant prior knowledge.

Familiarization. Following prequestions, the experimenter placed in front of the student a (12.7 cm x 20.3 cm) card with the passage typed on it. The experimenter then read the passage aloud and directed the student to read along silently. Then the prequestions were asked again and the student gave answers, referring to the passage when needed. Finally, the experimenter pronounced any words that the student had trouble pronouncing and had the student repeat these words.

Learning. A study-test procedure was used for learning. Students studied passages for 45 seconds, 1 1/2 minutes, or 3 minutes depending upon whether the passages were at a high, medium, or low prior knowledge level. The different study times were determined in a pilot study to result in roughly equal numbers of study-test trials per passage and, therefore, to result in equal numbers of overt repetitions across prior knowledge levels.

Participants were allowed to learn the passages using any approach that seemed normal to them (e.g., covert rehearsal) other than using a pen or pencil. During each test period, students said back what they could remember from the passage and the experimenter gave feedback, informing them of errors that had been made and of those parts of the passage that still had to be learned. Synonym substitutions were accepted as correct.

The criterion for learning was all but one proposition, which was 80-86% correct propositions, depending on the particular passage set. Passages were all 5, 6, or 7 propositions in length. Length was equal across levels of prior knowledge. The definition of propositions was essentially any independent clause. The choice of a criterion of all but one proposition correct was based on Underwood's (1964) suggestion that the amount of original learning can be equated best when the possibility of differential overlearning is avoided (i.e., when the learning task is uniformly interrupted at a level somewhat below mastery).

Seven subjects failed to reach criterion on their low prior knowledge passage and were therefore dropped from the data analysis. New subjects were assigned to the same conditions in order to fill out the Latin-square design.

Recall. Immediately after learning, students who had been assigned to the immediate recall condition were given a recall test on the passages learned. Students in the 4-week recall group were scheduled for a second visit in four weeks and told only that they would rate additional passages on how interesting they were. They were not forewarned of the delayed recall task in order to minimize the occurrence of rehearsal. At the second session, they performed a recall task identical to that of the immediate recall group and then rated some passages.

All participants recalled the passages in the order in which they had learned them. (For the immediate recall group this resulted in an average delay of 11 minutes between learning and recall.) They were given a blank sheet of paper with only the title of the passage at the top and asked to write down everything they could remember from the passage. The experimenter provided no additional recall cues but did assist in spelling words that students could pronounce but not spell. After the participant had finished, the experimenter instructed him or her to read what had been written once more and try to complete sentences and write down any additional sentences or words that came to mind. Then, the experimenter gave the student a sheet of paper with the title of the next passage that had been learned and continued in the same fashion until all three passages had been recalled.

After students in the 4-week condition had finished recalling, the experimenters asked about retention interval rehearsal. They asked participants if they had thought about any of the three passages, if they had repeated any of the passages or any parts of the passages to anyone and, if so, how much and how many times, and what the nature of the situation was in which they thought of or repeated parts of the passages. The amount of repetition for each passage was quantified and used as a measure of rehearsal in the data analysis.

Finally, students in the 4-week condition were asked what made them think of the sentences that they wrote down. Specifically, after subjects wrote down everything they could remember from the passage, the experimenter pointed to each sentence in the recall protocol and asked, "What made you think of this?" or, "What was going through your mind when you thought of this?" These questions were intentionally open-ended and not meant to cue any particular type of response.

Scoring Procedure

Protocols were scored for correct propositions and inferences. A proposition was defined as a subject-verb-object relationship. In the few cases where the verb had no object, a subject-verb relationship constituted a proposition. In cases where there was a compound verb or compound subject, two propositions were counted. This definition of propositions is most sensitive to recall of independent clauses. Dependent clauses and adjectival phrases were not counted as propositions as they are in Kintsch's scoring system (Kintsch, 1974; Turner & Greene, 1978). Our reason for defining propositions this way was that it simplified the monitoring process during learning. With a more complex definition of a proposition, the reliability of monitoring the attainment of the criterion would have decreased. Inferences were propositions that were either implied by the text or consistent with the text.

Three scorers scored the protocols. During three two-hour training sessions, the scorers refined the scoring procedure until everyone agreed on identical scores for 30 protocols chosen at random. As an additional control over interscorer reliability, each person scored equal numbers of passages from each prior knowledge level.

Results

Preliminary Analyses

Passage type and order of learning. Preliminary analyses of variance of the effects of passage type and order of learning on propositional recall revealed no significant effects, F (2,106) < 1 and F (2,106) < 1, respectively. The means and standard deviations for passage type wre: Factual, M = 2.89, s.d. = 2.23; Conceptual, M = 2.98, s.d. = 2.23; Narrative M = 3.06, s.d. = 2.32. The means and standard deviations for order of learning were: First, M = 2.91, s.d. = 2.06; Second, M = 3.09, s.d. = 2.30; Third, M = 2.93, s.d. = 2.39. Because no differences due to type and order were found, these factors were dropped in further analyses.

Time to learn. To determine differences in time to learn across levels of prior knowledge, the number of learning trials to criterion was multiplied by 45 seconds, 1 1/2 minutes, or 3 minutes, respectively, depending on whether the passage was a high, medium, or low prior knowledge passage, because these were the study times per trial for the different levels of prior knowledge. A one-way analysis of variance revealed a significant effect of prior knowledge on time to learn, $F(2,106) = 71.40$, $p < .001$. The means and standard deviations for time to learn (in minutes) were: High, $M = 1.26$, s.d. = .71; Medium, $M = 4.22$, s.d. = 2.72; Low, $M = 11.78$, s.d. = 8.60. This finding was expected and corroborates the notion that high prior knowledge speeds up the learning process.

Success in equating for original learning. Since one major goal was to examine retrieval effects of prior knowledge under conditions where the amount of original learning is controlled, it was important to assess the effectiveness of the learning-to-criterion procedure in equating different prior knowledge levels on original learning. Three different measures of original learning were used. If the different levels of prior knowledge were equated then (1) the number of propositions correctly recalled on the criterion trial should not differ as a function of prior knowledge, (2) immediate recall should not differ as a function of prior knowledge, and (3) the total number of overt repetitions of propositions during learning should not differ as a function of level of knowledge. Table 4 shows the means and standard deviations for each of these dependent variables as a function of level of prior knowledge.

Insert Table 4 about here

Inspection of these means suggests that the number of propositions correct on both the criterion trial and the immediate recall test did not differ significantly as a function of prior knowledge. These conclusions were verified by analyses of variance which showed no significant effect of prior knowledge on the number of propositions correct on the criterion trial, F (2,106) = 1.63, p = .20, and no significant effect of prior knowledge on immediate recall, F (2,51) = 1.73, p = .19.

Inspection of the means for the number of overt statements of propositions across learning trials suggests that the low prior knowledge passages produced more overt repetitions than did the high prior knowledge passages, with the medium prior knowledge passages falling in between. A one-way analysis of variance for the effect of prior knowledge on number of overt repetitions verified this observation, F (2,106) = 6.32, p = .003.

Taken together these data suggest that the experimental manipulation of learning-to-criterion produced the desired goal of equating for original learning in the sense that there were no differences in the ability to produce propositions at the end of learning or on immediate recall. The procedure was not successful in equating on the number of overt statements of propositions. However, the direction of the difference is opposite to the direction of predicted differences for the effect of prior knowledge on recall. That is, it is the low prior knowledge passages that produced the most overt repetitions during learning. Thus, if there is a bias in our procedure for equating original learning, it is one that favors the low prior knowledge condition.

Correct Propositions

Long-term recall. A one-way repeated measures analysis of variance revealed a significant effect of prior knowledge level on 4-week recall of propositions, F(2,51) = 3.23, $p < .05$. The average number of correctly recalled propositions in the 4-week condition were 1.70, .93, and 1.44, respectively, for passages having high, medium, and low prior knowledge levels. Scheffé tests revealed that .93 differed from the other two means.

The relatively high level of recall for the low prior knowledge passages was unexpected. However, we suspected that these passages, due to their novelty and to the unusually high motivation of the research participants, had been rehearsed more than the others during the retention interval and that this differential rehearsal explained their greater memorability. To examine this possibility, a one-way repeated measures analysis of variance was performed on rehearsal scores. This analysis revealed a significant effect of prior knowledge, F (2,51) = 5.18, $p < .01$. The average number of reported rehearsals of passages with low prior knowledge was greater ($M = 1.18$) than for passages with medium ($M = .74$) or high ($M = .70$) prior knowledge.

Because of the differential rehearsal of low prior knowledge passages, an analysis of covariance was conducted on recall using rehearsal as the covariate. (The assumption of homogeneity of regression was met.) A significant effect of prior knowledge was found, F (2,51) = 4.07, $p < .05$. The adjusted mean number of correctly recalled propositions for passages with high, medium, and low prior knowledge values, respectively, was 1.85, 1.04, and 1.19. (These means are shown in Table 5, along with the means obtained in Experiment 2.) Scheffé tests revealed that while the recall of high prior knowledge passages differed from the recall of both medium and low prior knowledge passages, recall of low and medium passages did not differ from each other. Thus, rehearsal appeared to account for the unexpectedly high recall of the low prior knowledge passages. When rehearsal effects were statistically removed, the results indicated that prior knowledge had a beneficial effect on the long-term recall of propositions.

Insert Table 5 about here

Predictions of long-term recall. Table 6 shows the correlations of long-term recall with passage attributes and with rehearsal. It also shows the correlations of the residual long-term recall score (with the effects of rehearsal partialled out) with each passage attribute. These correlations were determined across passages rather than across subjects, so that the scores for three subjects contributed to each observation on which the correlation was based, thus providing greater stability for each observation. As can be seen, when the effects due to rehearsal were partialled out, three passage attributes showed a signicant relationship to long-term recall. These were prior knowledge ($r = .52$), imagery ($r = .50$), and readability ($r = .41$).

Insert Table 6 about here

Table 7 shows the forward-selection stepwise multiple regression of passage attributes on residual recall scores. Prior knowledge was the first attribute selected by this procedure, producing a multiple R of .52 and accounting for 28% of the variance (that is $R^2 = .28$). The multiple R of all five attributes was .57 and accounted for 33% of the variance.

Thus, it appears that prior knowledge is the strongest single predictor of recall among the five passage attributes measured. It also is evident, from the correlations, that imagery is almost as good a single predictor as is prior knowledge. Finally, the difference in amount of variance accounted for by prior knowledge alone and the five attributes taken together is not very substantial (5%). Because prior knowledge and imagery were about equal in their association with recall and were also almost completely overlapping in their effects we tried to separate out their effects in a later experiment, labelled Experiment 3 in this report.

Insert Table 7 about here

Inferences

Inferences were ideas that did not match ideas explicitly stated in the text but were plausible additions. There was almost no inferential recall in the immediate recall condition. However, for 4-week recall, some subjects wrote down plausible inferences. These tended to be such things as adding details or integrating ideas. For example, for a narrative about a woman running a race, one inference was that "she stretched her muscles before the race so that she could run faster." Or, for a conceptual passage about AA quality eggs in which it was stated that AA quality eggs have a thick yolk, an inference was that "low quality eggs have a thin yolk."

Table 8 shows the number of inferences produced at 4-week recall as a function of passage type and amount of prior knowledge. These data were not of sufficient quantity to analyze statistically; nonetheless, several observations are worth making. First, as prior knowledge increases, the number of inferences increases. Second, this increase appears to occur only in conceptual and narrative passages. Third, narrative passages produced the most inferences and factual produced the least.

Insert Table 8 about here

Retrospective Reports

Analysis of responses to the question "what made you think of this?" revealed three major categories: (1) responses that reflect elaborations based on prior knowledge, (2) responses that reflect elaborations based on the learning episode, and (3) "I-don't-know" responses. Examples of responses based on prior knowledge are "we learned about alloys in chemistry class" where the target proposition was "Zinc aluminum alloys are useful to mankind" or "novels have settings" where the target was "the setting was often in northern England." An example of a response based on the learning episode was "I remembered that one was the last sentence." A typical I-don't-know response was "it just popped into my mind."

A scorer who was unfamiliar with our predictions was trained to classify students' reports into one of the above three categories. The proportions of prior knowledge, learning episode, and I-don't-know responses, as a function of prior knowledge level are shown in Table 9.

Insert Table 9 about here

As can be seen, the proportion of responses that could be interpreted as elaborations based on prior knowledge was far greater for the high prior knowledge passages (.45) than for the medium (.25) and the low (.13) prior knowledge passages. Thus, the students remembered more from high prior knowledge passages and also reported a greater proportion of elaborations based on prior knowledge used as retrieval cues. These data suggest that new information that contains familiar concepts stimulates elaborative encoding and that the elaborative encoding provides multiple retrieval pathways.

Experiment 2

Experiment 1 demonstrated that prior knowledge beneficially affected long-term recall of information learned from text in a group of quite able suburban students. However, prior knowledge also produced differential rehearsal in that experiment. The purpose of Experiment 2 was to replicate the results of Experiment 1 with average rural students in a situation in which differential rehearsal did not occur. To reduce the possibility of rehearsal (1) the experiment was conducted as part of the regular school day so that no undue attention would be put on the procedure, and (2) prior knowledge was made a between subject factor so that there was no contrast effect calling attention to the less familiar passages.

Two other changes were made in this experiment. First, only four passages were used (two factual and two conceptual) because the point was already made in Experiment 1 that the results were general across passage type. Second, the retention interval was reduced from four weeks to one week because recall at four weeks was at a low level in Experiment 1.

Subjects

The participants were 40 seventh and eighth grade students of average reading ability (based on national norms). They were from rural school districts and participated in the study during school hours.

Design

The design was a 2 x 2 design with one between-subject factor (prior knowledge level--high or medium) and one within-subject factor (passage type--factual or conceptual). Only long-term recall was measured in this study, the assumption being that the last performance during learning served as an immediate recall measure.

Materials

The materials were the high and medium prior knowledge passages from one conceptual and one factual passage set used in Experiment 1. Specifically, these were German Chocolate Cakes, Zinc Alluminum Alloys, Henry James, and Thomas Gray.

Procedure

Experimenters traveled to the schools and were each provided with quiet rooms where they supervised equal numbers of students one at a time in each condition. Each participant was randomly assigned to either the high or the medium prior knowledge condition and learned two passages to criterion, one each from the conceptual and the factual set. Order of learning was balanced in the design and randomly assigned to participants. The same prequestions as in Experiment 1 were asked and the same study-test procedure for learning was used.

One week later, students returned for an unanticipated recall test. They were informed that they could choose not to take the test, but none so chose. The entire group of students who participated in the study in any given school took the recall test together. Other than the change to group testing and the change from a 4 to 1 week recall interval, the conditions of the recall test were indentical to those described in Experiment 1.

After the students finished writing down all they could remember, they filled out a detailed questionnaire concerning how often they had thought about each passage, how many times they had told someone of each of the passages, and how many times they had repeated parts or all of each passage to themselves or to someone else. These answers were quantified and used as a measure of rehearsal. Finally, the students were given a full explanation of the study along with helpful hints on how to remember things.

The recall protocols were scored for correct propositions by an experienced scorer.

Results

Rehearsal. In order to investigate the effects of prior knowledge level on rehearsal, a one-way analysis of variance was computed with prior knowledge the between-subject factor. No significant difference due to prior knowledge was found, $F(1,39) = .92$. The mean number of rehearsals for high and medium prior knowledge passages, respectively, were 2.76 and 3.25.

Recall of propositions. A two-way ANOVA on propositional recall scores revealed no significant effect for passage type, $F\ (1,39) = 1.03$, nor for the interaction of passage type and prior knowledge, $F\ (1,39) = 1.46$. However, the effect of prior knowledge was significant, $F\ (1,39) = 6.78$, $p < .02$. The high prior knowledge passages ($M = 2.60$) were recalled significantly better than the medium prior knowledge passages ($M = 1.38$). These means are shown in Table 5, along with corresponding means from Experiment 1.

Thus, the results found in Experiment 1 were replicated in Experiment 2. In both studies, passages of high prior knowledge levels were recalled better than passages of medium prior knowledge levels. This finding was obtained under conditions where the number of target propositions represented in long-term memory was equated.

Experiment 3

The correlation analysis reported in Experiment 1 showed that the imagery value of the passage could account for the results almost as well as the prior knowledge value. Therefore, the purpose of Experiment 3 was to assess the independent contributions to recall of imagery and prior knowledge.

Subjects

Participants were 40 seventh and eighth graders of average and above average reading ability. They were paid for participation.

Design

The design was a two group design. Both groups learned the same control passage. In addition, one group learned a passage that differed from the control passage on imagery but not on prior knowledge value and the other group learned a passage that differed from the control passage on prior knowledge but not on imagery.

Materials

Three of the passages used in Experiment 1 were used. The relevant attributes of these passages are shown in Table 10. The first passage in the table, Sigunde, served as a control passage in the sense that all students learned and recalled this passage. In addition, half of the students learned the passage titled German Chocolate Cakes and half learned the passage titled Zinc Aluminum Alloys. As can be seen, the German Chocolate Cakes passage is not different from Sigunde on the dimension of imagery, but is different from it on the dimension of prior knowledge. Both passages stimulate an average of about three images; however, the Cakes passage has a much higher prior knowledge score: 23.71 versus 15.79 for Sigunde. This difference is the size of one standard deviation on the prior knowledge scale. By contrast, the Zinc Aluminum Alloys passage is similar to Sigunde on prior knowledge (16.73 versus 15.79), but Sigunde has a higher imagery score: 3.13 versus only 1.83 for the Alloys passage, or a difference of two standard deviations.

The Alloys and Cakes passages were from the same passage set so they had the same syntactical structure. Thus, the two groups each learned a passage that (a) differed from the control passage on only one of the two dimensions of interest, and (b) did not differ from each other on irrelevant dimensions such as passage type and syntax.

Insert Table 10 about here

Procedure

Students were randomly assigned to one of the two groups. Each student learned two passages, Sigunde and one of the other two passages, in the same manner and to the same criterion as was used in Experiments 1 and 2. Passage order was counterbalanced across groups. After one week, participants free-recalled the passages, and reported rehearsal activities. Protocols were scored for correct propositions in the same manner as in the previously reported experiments.

Results

The difference in number of propositions recalled for Sigunde versus the other passage was the main datum of interest. The mean difference between Cakes and Sigunde was .80 while the mean difference between Sigunde and Alloys is -.15. The former difference is reliably different from zero, $t(19) = 2.29$, $p < .05$, while the latter is not.

Cakes and Sigunde differed on prior knowledge, so these results suggest that prior knowledge is important for facilitating retrieval while imagery is not. The failure to find an effect of imagery on delayed recall is impressive because the imagery values of the control and experimental passages differed by two standard deviations. The prior knowledge difference, which did yield an effect, was only one standard deviation.

Discussion

The two purposes of these studies were (1) to examine the role of prior knowledge in retrieval processes, and (2) to assess the utility of a quantitative, content-free measure of prior knowledge. Each of these goals will be discussed in turn.

Prior Knowledge and Retrieval

In all three experiments, the level of prior related knowledge was varied, while the amount of text information in memory at the start of the retention interval was controlled. In all experiments, recall was higher with more prior knowledge. Since initial learning was controlled, the effect obtained must be due to *how* the information was encoded rather than to *whether* it was encoded. Specifically, we believe that the passages for which subjects had low prior knowledge were encoded less elaborately than were the passages for which subjects had high prior knowledge (see Figure 1) because prior knowledge forms the basis for generating elaborations (for example, inferences, details, or examples not provided by the text). A more elaborate encoding facilitates recall in two ways. First, it provides multiple retrieval pathways for a spread-of-activation retrieval mechanism (J. Anderson, 1976). If activation fails to spread from the cue (in this case, the title) to the target proposition, it may nonetheless spread from the cue through an elaboration and to the target proposition, thus increasing the probability of recall. Second, the elaborations provide useful data for reconstructive recall (Reder, 1979), and thus increase the amount of information that can be reconstructed.

Several aspects of our data support this elaborative processing interpretation of the role of prior knowledge. First, the retrospective reports collected in Experiment 1 show that subjects elaborated more on the high prior knowledge passages than on medium or low prior knowledge passages. Second, there is independent evidence from the norming study (Gagne, et. al., 1981) that the high prior knowledge passages stimulate more potential elaborations than do medium or low prior knowledge passages. Finally, some of the inferences produced in Experiment 1 were probably elaborations that the subject generated at encoding or during the retention interval. The fact that more inferences were produced for high prior knowledge passages than for medium or low prior knowledge passages suggests that more elaborations were produced for these passages.

We considered several alternative explanations of how prior knowledge influences retrieval processes and found that they were not consistent with all of the data. One alternative was that prior knowledge stimulates rehearsal behavior and passages that are rehearsed more are better recalled. However, in Experiment 1 high prior knowledge passages were actually associated with less, rather than more, rehearsal, and in Experiments 2 and 3 there were no significant effects of prior knowledge on rehearsal. So, even though there is a positive relationship between rehearsal and recall, prior knowledge has an independent effect on recall. Hence, the positive effect of prior knowledge on recall must be explained independently of the effect of rehearsal on recall.

Another explanation we considered was that the differences obtained are "just" due to the fact that the vocabulary is more difficult in the low prior knowledge passages. In fact, we consider vocabulary knowledge to be an important part of our explanation. However, there are other types of prior knowledge, such as personal events, and descriptive, and comparative information that are not part of a word's definition, yet are important in stimulating elaboration. This non-definitional related knowledge must be playing an important role over and above vocabulary knowledge since prior knowledge (i.e., both definitional and other information) correlates much more highly with recall (.52) than does word frequency (.17), which is a good stand in measure for definitional knowledge. (Word frequency is a good stand-in measure for definitional knowledge if one assumes that it is adaptive to learn the definitions of frequently used words). Future studies should look at the qualitative aspects of prior knowledge that account for its utility in stimulating recall.

A final alternative explanation considered was one emphasizing imagery. A "dual-encoding" view of memory claims that highly imageable material is stored in both verbal and imaginal form and that, therefore, there are more redundant retrieval paths to such material relative to less imageable material (Paivio, 1975). Since, in general, the high prior knowledge passages were also the highly imageable passages, the dual-coding hypothesis is plausible if one considers the results of Experiments 1 and 2 only. However, the results of Experiment 3, indicating an effect of prior knowledge but no effect of imagery, suggest that this explanation is not useful in explaining differences in long-term recall of text.

In summary, the data demonstrate an important role for prior knowledge in retrieval processes. Its role appears to be as a stimulator of elaborations. The elaborations are then stored in the knowledge structure along with text information, providing cues for reconstructive recall and/or alternative retrieval paths for spread-of-activation.

Quantitative, Content-Free Assessment of Prior Knowledge

The measure of prior knowledge used here was the number of sentences generated by a norming group in response to the target sentences. The average number of sentences generated for high, medium, and low prior knowledge passages, respectively, was 26, 16, and 7. This quantitative measure made it possible to compare prior knowledge with other quantitative measures of passage attributes (interest, imagery, word frequency, and readability) to see which had the greatest impact on long-term recall. Many previous studies of prior knowledge have implicitly confounded these variables. We were able to explicitly confront this confounding and come to some reasonable conclusions about which variables were most important. The two most important variables, prior knowledge and imagery, were then pitted against one another experimentally to determine which of the two was the causal variable. Thus, quantitative measurement helped us make important decisions about prior knowledge.

The same measure of prior knowledge was used on passages that varied in type (conceptual, factual, or narrative), in content, and in syntax. Previous measures of prior knowledge have been more specifically tied to content and hence questions of the general effects of prior knowledge could not be answered directly. In Experiment 1 of this study it was found that the effects of prior knowledge on recall of propositions were similar across passages of different content and passage type while the effect of prior knowledge on generation of inferences appeared to be different depending on the type of passage. Neither of these findings could have been obtained without having a content-free measure of prior knowledge.

Thus, our measure of prior knowledge is useful in studying quantitative questions about prior knowledge and in studying questions of generalizability.

Educational Implications

Prior knowledge is of substantial importance. The size of the effect of prior knowledge is large. Almost 30% of the variation in long-term recall can be accounted for by the amount of prior knowledge a person has relevant to a topic, irrespective of the quality of this knowledge. The first educational implication to be drawn, then, is that quantity of prior knowledge is a variable worthy of teacher attention.

Provide or stimulate prior knowledge. It is easy to imagine how one might take advantage of prior knowledge on an individual basis, by tailoring lessons to a student's unique knowledge background. However, in a group situation where each student's knowledge is somewhat different, it is more difficult to take advantage of prior knowledge. A technique used in several approaches to reading, however, seems promising. Essentially, the technique involves asking questions prior to reading that stimulate recall of prior knowledge in students who have prior knowledge while at the same time providing prior knowledge for students who don't have it. In content area reading, an approach called the "Instructional Framework" (Herber, 1970) uses this technique. In elementary school reading, an approach called "PReP" (Langer, 1981) uses this technique. Langer and Nicolich (Note 2) have demonstrated that the PReP approach has benefits for long-term recall.

Imagery instructions stimulate recall of prior knowledge and elaborative processing. Many studies have demonstrated the utility of having students (especially young ones) create images for what is being learned. We have no quarrel with these results. It is clear that imagery strategies are quite powerful. However, we do quarrel with a "dual-encoding" interpretation of the effectiveness of imagery instructions. The results of Experiment 3 suggest that it is the amount of prior knowledge and not imagery per se that causes improvements in memory.

It appears to us that imagery is a processing mode in working memory that tends to make a lot of prior knowledge simultaneously available and hence encourages elaborative processing. Young children may benefit from this working memory mode more than older children or adults because their skills in the language processing mode are less highly developed. The educational implication of this interpretation of the effects of imagery instructions, then, is that imagery instructions are one of a variety of techniques that can be used to stimulate recall of prior knowledge and elaborative processing.

Readability formulae have limited value in predicting memory for discourse. In Experiment 1 it was found that readability correlated with long-term recall .41 whereas prior knowledge correlated with long-term recall .52. Thus, prior knowledge is a better single predictor of long-term recall than is readability. Miller and Kintsch (1980) have also found that readability is not a good predictor of memory outcomes. Since it is hoped that the benefits of reading text are more or less permanent, these findings suggest that we should reevaluate our reliance on readability formulae as a method of evaluating textbooks.

Do slow students in mastery learning programs remember as much as fast students? Mastery learning programs are based on the assumption that it doesn't matter how a person learns something as long as she or he learns it. This assumption may be correct for procedural knowledge (i.e., intellectual skills and cognitive strategies) but the present data suggest that it is not correct for declarative knowledge. Specifically, students who must go through a lesson several times before reaching criterion are like our subjects in the low prior knowledge condition. They are reaching criterion by dint of sheer repetition rather than through the generation of an elaborated knowledge representation. Therefore, such slow students may forget more than faster students even though they reach the same criterion. This prediction is perhaps the most important educational implication deriving from the studies reported here because it is directly based on the learning to criterion procedure which is a unique aspect of our studies.

Conclusion

We have presented evidence that the quantity of prior knowledge plays an important role in the retrieval and reconstruction of information from long-term memory. Explanations of this role in terms of a greater amount of new information represented in long-term memory, more rehearsal, greater word frequency or more imagery have been discounted. There is consistent support, however, for an elaborative processing explanation.

Reference Note

1. Langer, J. & Nicolich, M. Effect of altered prior knowledge on passage recall. Paper presented at the National Reading Conference, San Diego, 1980.

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Table 1

Titles of the 27 Passages Used in Experiment 1

Set 1	Set 2	Set 3
	Factual	
Governor Smith	Washington, D.C.	Henry James
Emperor Hollingshead	Stockholm	Thomas Gray
Premier Chang	Accra	Wolfram von Eschenbach
	Conceptual	
AA Quality Eggs	German Chocolate Cakes	Piano
Superior Goldfish	Zinc Aluminum Alloys	Fire
Cum Laude Theses	Organic Halogen Amalgamations	System
	Narrative	
Nancy	Carol	Susan
Sigunde	Eric	Raoul
Babanam	Leatha	Francois

Note: Within each of the three sets of a given passage type (factual, conceptual, narrative) one passage each was of a high, medium, or low prior knowledge level. However, all passages within a set had a constant syntax.

Table 2

Sample Set of Factual Passages Varying on Prior Knowledge Level While Maintaining Constant Syntax

High Prior Knowledge: Henry James
Henry James wrote historical novels.
Many novels described states of mind produced by human actions.
The setting was often in northern England.
Portrait is one of James' novels.
It discusses the states of mind produced by human actions.
The main character in the novel is an American woman in old Europe.

Medium Prior Knowledge: Thomas Gray
Thomas Gray created eloquent verse.
Many verses enumerated truisms of the Divine romanticized in meditative bliss.
The philosophy was often of heartfelt action.
"Elegy" is typical of Gray's verse.
It presents truisms of the Divine romanticized with meditative bliss.
The subject matter in the verse is the universal dignity in common mortality.

Table 2 (Continued)

Low Prior Knowledge: Wolfram von Eschenbach

Wolfram von Eschenbach composed Homeric Epics.

Many epics elucidated the quest for the Grail concommitant with quotidian chivalry.

The schemata was often from Wartburgian annals.

Parzival is exemplary of Eschenbach's epics.

It delineates the quest for the Grail concommitant with quotidian chivalry.

The trenchant protagonist in the epic is a guileless novitiate in consecrated indenture.

Table 3

Attributes of Passages Varying on Prior Knowledge

Prior Knowledge	Imagery[a]	Interest[b]	Readability[c]	Word Frequency[d]
High	3.70	3.36	71.78	163.73
Medium	2.55	2.93	42.67	69.30
Low	1.47	2.12	26.89	22.06

[a] Average number of images stimulated by reading the passage.

[b] 1 = very boring, 5 = very interesting.

[c] 0 = very difficult, 100 = very easy.

[d] Frequency of occurrence of word per 1,000,000 words.

Table 4

Means and Standard Deviations for Number of Propositions Correct on the Criterion Trial, Number of Propositions Correct at Immediate Recall, and Number of Overt Statements of Propositions across Learning Trials As A Function of the Prior Knowledge Level (P.K.) of the Passage

Propositions Correct on Criterion Trial			
	High P.K.	Medium P.K.	Low P.K.
M	5.91	5.76	5.67
s.d.	.95	.84	.92

Propositions Correct at Immediate Recall			
	High P.K.	Medium P.K.	Low P.K.
M[a]	4.96	4.63	4.19
s.d.	1.22	2.00	1.80

Number of Overt Statements of Propositions across Learning Trials			
	High P.K.	Medium P.K.	Low P.K.
M	9.29	10.38	11.98
s.d.	4.77	4.93	5.43

[a] The average number of propositions across passages was 6.11.

Table 5

Mean Number and Percentage of Propositions Recalled as a Function of Prior Knowledge

Prior Knowledge	Experiment 1[a]	Experiment 2[b]
High	1.85 (37%)	2.60 (52%)
Medium	1.04 (21%)	1.83 (37%)
Low	1.19 (24%)	Not included

[a] Above-average students, scores adjusted for rehearsal, a 4 week retention interval.

[b] Average students, controlled for rehearsal, 1 week retention interval.

Table 6

Correlations of Long-Term Recall, Residual Long-Term Recall (Effects Due To Rehearsal Partialled Out), and Rehearsal with Passage Attributes

	Recall	Residual Recall	Rehearsal	Prior Knowledge	Imagery	Interest	Read-ability	Word Frequency
Recall	1.00	.84**	.55**	.20	.32	.20	.13	.00
Residual Recall		1.00	.17	.52**	.50**	.36	.41*	.17
Rehearsal			1.00	-.42*	-.20	-.23	-.33	-.30

* p < .05

** p < .01

Table 7

Multiple Regression of Passage Attributes on Residual Long-Term Recall Scores (Effects Due to Rehearsal Partialled Out)

Attribute	Multiple R	R^2	R^2 Change
Prior Knowledge	.52	.28	.28
Word Frequency	.54	.30	.02
Interest	.54	.30	.00
Imagery	.57	.33	.03
Readability	.57	.33	.00

Table 8

Frequency of Plausible Inferences Occurring in Recall Protocols

As A Function of Amount of Prior Knowledge and Passage Type

	Type of Passage			
	Conceptual	Narrative	Factual	Across Types
Prior Knowledge				
High	12	20	1	33
Medium	8	6	0	14
Low	1	6	2	9
Across Levels of Prior Knowledge	21	32	3	

Table 9

Retrospective Self-Reports of What Stimulated Recall of Target Propositions

Prior Knowledge Level	Type of Response		
	Prior Knowledge Elaboration	Learning Episode Elaboration	I-don't-know
High	.45	.15	.40
Medium	.25	.25	.50
Low	.13	.40	.47

Note: The numbers are proportions of all responses within a given level of prior knowledge.

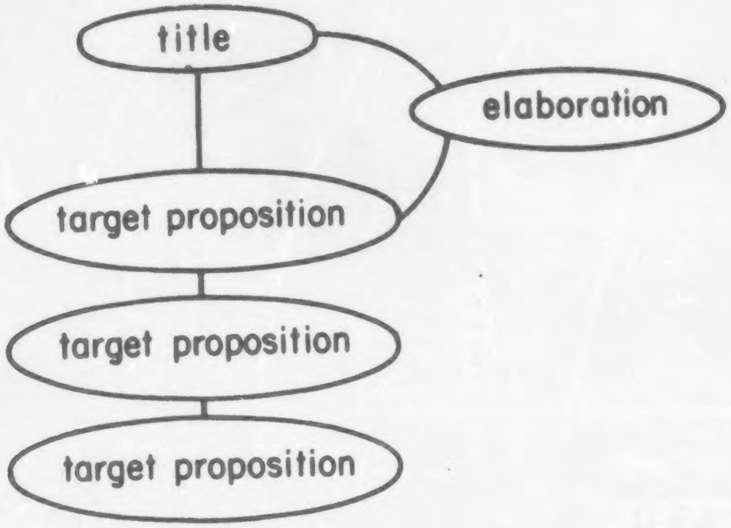
Table 10

Attributes of Passages Used in Experiment 3

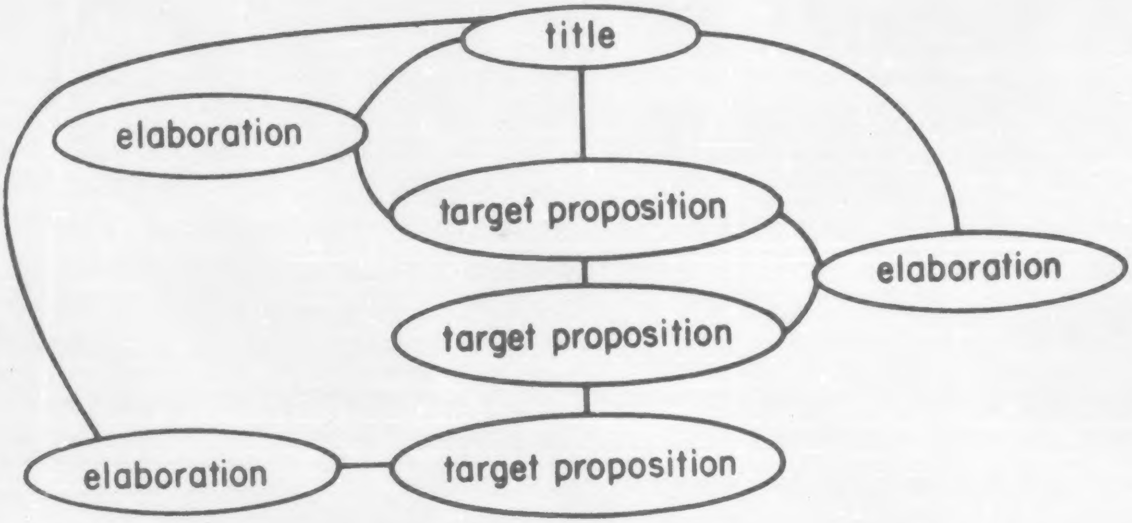
Passage	Prior Knowledge	Imagery Score
Sigunde (Control Passage)	15.79	3.13
German Chocolate Cakes	23.71	3.02
Zinc Aluminum Alloys	16.73	1.83

Figure Caption

Figure 1. Hypothetical network structures surrounding three target propositions under conditions of (a) low, and (b) high prior related knowledge. The target propositions in the low condition have few elaborations associated with them while the target propositions in the high condition have many elaborations associated with them. The elaborations provide alternate retrieval pathways and also clues for reconstructive recall.


title
elaboration
target proposition
target proposition
target proposition

(a) Low Prior Related Knowledge


title
elaboration
target proposition
elaboration
target proposition
elaboration
target proposition

(b) High Prior Related Knowledge

APPENDIX 3

The Effects of Text Familiarity and Cohesion on Retrieval of Information Learned from Text

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Running head: Text Familiarity and Retrieval

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Abstract

This study examined the effects of familiarity of passage concepts and passage cohesion on retrieval of text information. In order to distinguish between comprehension and retrieval processes, subjects were equated on comprehension. Therefore, any differences found could be attributed to differences in retrieval processes. The passages used varied on familiarity and cohesion, but syntax was held constant.

Middle school students learned information in passages to an 85% correct criterion using a study-test procedure. The subjects were not told that they would be tested on the material. Two weeks later, they took a free recall test and reported their rehearsal of the passage information during the intervening time period.

The results showed that although the original amount learned was equated, recall of propositions from passages with more familiar concepts was about 35% greater than the recall from passages with less familiar concepts. There were no significant differences due to cohesion or the interaction of cohesion and familiarity. The explanation presented is that familiarity stimulates elaboration of passage material and elaborations provide alternate retrieval pathways at recall. Educational implications are discussed.

The Effects of Text Familiarity and Cohesion on Retrieval of Information Learned from Text

The long-term recall of information learned from text is an important outcome of content area reading. The importance of information retrieval in problem-solving (cf. Maier, 1930), inductive reasoning (cf. Bruner, Goodnow, & Austin, 1956), inference-making (cf. Frase, 1973; Hayes-Roth & Thorndyke, 1979), and decision-making (cf. Kahneman & Tversky, 1972) has been well documented. Because of its importance it would be useful to know which factors influence long-term recall. The present study was designed to shed some light on this question. Specifically, we were interested in the effects on long-term recall of (1) familiarity of passage concepts, and (2) passage cohesion.

Long-term recall appears to be enhanced by elaborate encoding because an elaborate encoding of information provides alternative retrieval pathways (Anderson & Reder, 1979; Gagné, 1978) and clues for reconstructive recall (Reder, 1980). Compare, for example, the likely encodings for the following two sentence pairs:

(a) Smith's father was a jewelry storekeeper.
Smith's favorite sister likes jewelry very much.

and

(b) Hollingshead's sire was a travelling cooper.
Hollingshead's esteemed sibling appreciates sonnets considerably.

Very likely, a school-age reader of pair (a) would have something like the following thoughts while reading the above sentences: "Smith's sister likes jewelry because she grew up around it;" "I like jewelry too;" "I buy jewelry at Brown's Jewelry on Main Street." By contrast, a similar reader of sentence pair (b) would have few thoughts over and above the ideas stated in the sentences. Hence, sentence pair (a) would be more elaborately encoded than sentence pair (b). That is, for sentence pair (a), not only would the information in the text sentences be stored, but also the reader's additional thoughts would be stored along with text information. This elaborate encoding could provide multiple retrieval pathways for direct recall and also provide clues for reconstructive recall. For example, if the reader couldn't at first remember that Smith's father was a jewelry storekeeper but could remember thinking about Brown's Jewelry Store this could then lead to the recall of the passage idea.

What accounts for the different encodings for pairs (a) and (b)? First, young readers possess more knowledge that is relevant to sentence pair (a) than to sentence pair (b). For pair (a), they know what all the words mean and they have personal experience related to the topics of jewelry, stores, and sisters, but for pair (b) they either don't know what the words mean (e.g. "siblings") or they don't have much experience related to a topic even if they know its meaning (e.g. "cooper"), or both. Knowledge of word meanings and other information related to a topic provides the basis for elaborate encoding.

A second difference between sentence pair (a) and sentence pair (b) is that pair (a) repeats a concept (jewelry) across sentences and thus stimulates the reader to relate the two sentences (e.g. "Smith's sister likes jewelry because she grew up around it"). Sentence pair (b) does not repeat concepts across sentences and hence is less likely to stimulate an attempt to integrate the ideas from the two sentences.

Thus, both the greater familiarity of concepts in sentence pair (a) and the greater cohesion of pair (a) should encourage an enriched encoding. This enriched encoding, in turn, should lead to better long-term recall.

The purpose of the study reported here was to test the predictions that more familiarity with passage concepts and more passage cohesion increase the probability of long-term recall of passage information. To test these predictions, seventh and eighth graders learned and recalled two weeks later some short (6-sentence) passages. The passages varied orthogonally on cohesion (defined as the repetition of concepts across sentences) and familiarity of passage concepts (determined in a norming study (Gagné, Bell, Yarbrough, & Weidemann, 1981).

Method

Subjects. Thirty-two seventh and eighth grade students participated in the study for a payment of $3.00. Their scores on the reading subtest of the Comprehensive Test of Basic Skills were average or above average on national norms.

Design. The design was a 2 x 2 factorial with one between- and one within-subject factor. The between-subject factor was familiarity (either high or moderate) and the within-subject factor was cohesion (either high or low). Subjects were randomly assigned to the high or moderate familiarity condition. A 2 x 2 Latin-square design was used to balance passage content and passage order across levels of familiarity and cohesion.

Materials. There were four passages used in the study, two highly familiar passages and two moderately familiar passages. These passages are shown in Table 1.

Insert Table 1 about here

Familiarity was manipulated by varying the difficulty level of vocabulary in the passages while keeping the information new. That is, in highly familiar passages, the concent and/or concept labels were well-known but the ideas relating the concepts were new. However, in the moderately familiar passages *neither* the concepts (concept labels) *nor* the ideas relating the concepts were well-known.

Our assumption was that passages with familiar concepts would stimulate the reader to think of related prior knowledge. To test this assumption we normed the passages on an independent group of seventh and eighth graders (Gagné, et al., 1981). In the norming study, subjects were given two minutes per sentence to write down every idea they could think of related to concepts in the passage sentence. (For example, "My hobby is chess" was an appropriate response to "Governor Smith has many hobbies"). The average number of ideas so written by roughly 20 subjects was the measure of familiarity with the concepts used in the passages. This average was 28.29, and 23.63 ideas for the *Governor Smith* and *Henry James* passages, respectively, and 10.96 and 17.06 for *Emperor Hollingshead* and *Thomas Gray* passages, respectively. *Governor Smith* and *Henry James* were the highly familiar passages and *Emperor Hollingshead* and *Thomas Gray* were the moderately familiar passages.

Syntax was held constant across levels of familiarity, in order to rule out an explanation of the results based on syntactical complexity.

There were two forms of each passage--one high in cohesion and one low in cohesion. The high cohesion forms had more repetitions of concept labels across sentences. For example, the high cohesion form of *Governor Smith* repeated the concept labels *hobby*, *jewelry*, and *sister* in at least two different sentences, while low cohesion form did not (See Table 1). Instead *dog*, *bakery*, and *children* were substituted in the analogous sentences in the low cohesion form. However, across both forms, the last three sentences were identical. In the results, we examined only recall from the last three sentences since recall from the first three sentences might be affected by the slightly different content.

Procedure. The study was conducted on an individual basis in university classrooms. Each subject learned two passages (one high cohesion and one low cohesion, in counterbalanced order) to a criterion using a study-test procedure. The criterion was the oral recall of the subject, verb, and all the repeated concepts (or their analogs) from the first three sentences and roughly 85% of the propositions from the last three sentences. Having a less than 100% criterion helps prevent overlearning effects (Underwood, 1964). Propositions were defined by Kintsch's procedure as described in Turner and Greene (1978).

Prior to showing the subject the passage, the experimenter asked a question about each sentence. The purpose of the prequestions was twofold--first, it assured us that subjects did not already know the particular facts stated in the passages, and second, it caused the subjects to bring to mind their relevant prior knowledge. After asking the prequestions, the experimenter read the passage aloud and the subject read it silently from the 5 x 8 inch card on which it was typed. Following the reading of the passage, the experimenter asked the same questions and the subject answered them, referring to the passage as needed.

Following this introduction to the passage, subjects were given either 1 1/2 minutes (moderately familiar passages) or 45 seconds (highly familiar passages) to study the passage. The purpose of different study times was to equate for the number of overt repetitions of the passages during learning. (Had study times been equal the moderately familiar passages would have been overtly repeated more often.) After study, the card on which the passage was typed was removed and the subject repeated what could be remembered. Study-test trials were repeated until 85% of the information from the last three sentences could be recalled.

Following learning, subjects were thanked for their assistance and paid $3.00. They were not informed that there would be a long-term recall test.

From 5 to 17 days after learning, subjects were contacted by telephone.[1] The average delay, 15 days, was equal across groups. Subjects were instructed to write down the title (provided by the experimenter) of the first passage they had learned. They then wrote down all the ideas they could remember from that passage and read their responses to the experimenter. Then the same procedure was followed for the second passage. Finally, subjects were asked how many times they had recited aloud or in their minds part or all of each passage since learning it. The answers to these questions formed the measure of rehearsal.

Scoring of free recall. Recall of the first three sentences of the passage was not scored because there were content word differences in these three sentences. Recall from the last three sentences was scored by a person trained to use Kintsch's procedure as described by Turner and Greene (1978). In this procedure, the text base is analyzed into its underlying propositions. Then, the free recall protocol is scored for matches between its propositions and text base propositions (synonyms were accepted). The number of matches is the number of propositions correctly recited. The text base propositions for the last three sentences in Governor Smith are shown in Table 2. There were few inferences produced and these were not analyzed.

Insert Table 2 about here

Results

Preliminary Analyses

Two preliminary analyses were conducted to determine whether original learning and rehearsal were equated across treatments. If they were, then group differences in long-term recall would have to be accounted for by something other than different amounts of learning or rehearsal.

A third analysis was performed on time to reach criterion. This was done as a manipulation check. If subjects are cooperating, then high, familiar passages are learned faster than moderately familiar passages.

Original learning. Subjects were equated for original learning in that they all reached the same criterion. (Statistical checks on the success of this procedure are reported elsewhere (Gagné, Yarbrough, Bell, & Weidemann, Note 1). Another way to check on equating for learning is to see whether the number of overt repetitions of propositions during learning was the same across treatments. A 2 x 2 analysis of number of overt repetitions revealed no significant effects for familiarity, cohesion, or the interaction of familiarity and cohesion. Thus, success in equating for original learning across treatments was achieved by having both the same learning criterion and the same number of overt repetitions during learning. Therefore, any differences in long-term recall that are found cannot be attributed to differences in original learning.

Rehearsal. Rehearsal was defined as the number of overt or covert repetitions that subjects reported during the retention interval. A 2 x 2 analysis of variance with repeated measures on the cohesion factor revealed no significant effects of the experimental variables on number of reported rehearsals. Thus, rehearsal was equated across treatments. This finding means that any differences in long-term recall that are found cannot be attributed to differential rehearsal during the retention interval.

Time to learn. A 2 x 2 analysis of variance with repeated measures on the cohesion factor revealed a significant main effect of familiarity on time to learn (study time only), F (1,30) = 35.64, $p < .001$. The average learning time (in minutes), for the highly familiar passages was shorter (M = 2.03) than that for the moderately familiar passages (M = 6.52). It is well known that familiar material is learned faster than unfamiliar material. Since this result was replicated here, it suggests that subjects were cooperating.

Neither cohesion nor the interaction of cohesion and familiarity influenced time to learn.

Long-Term Recall

The means and standard deviations for number of target propositions correctly recalled are shown in Table 3. As can be seen, the average number of propositions recalled from highly familiar passages (*M* = 5.00) was substantially higher than that recalled from moderately familiar passages (*M* = 0.60). The percent recalled for highly familiar passages was 39% while it was only 5% for the moderately familiar passages. An analysis of variance revealed that this difference was significant, $F(1,30) = 46.32$, $p < .001$.

Insert Table 3 about here

Neither the main effect of cohesion, $F(1,30) = 1.67$, $p = .21$, nor the interaction of cohesion and familiarity ($F < 1$) significantly affected recall.

Discussion

The beneficial effects of familiarity and cohesion on comprehension are well known. However, it has not been demonstrated whether these variables have independent effects on retrieval. The purpose of this study was to examine the effects of familiarity and cohesion on retrieval processes. In order to isolate retrieval from encoding, passages that varied on familiarity and cohesion were learned to the same criterion. The results revealed a sizeable effect of familiarity on two week recall, but no effect of cohesion. The positive effect of familiarity on recall may be limited to short passages since it has not been demonstrated on passages longer than one paragraph. However, the generality of these findings to short passages was suggested by a previous study in which the authors demonstrated the positive effect of familiarity on the recall of 27 different passages of both expository and narrative structure (Cagné et al., Note 1).

What accounts for the effect of familiarity? As was stated in the introduction, we believe that readers possess prior knowledge about familiar concepts. The prior knowledge consists of both knowledge of the meaning of concept labels and knowledge of other facts about the concepts. This knowledge stimulates elaborative processing of new information. These elaborations then provide alternate retrieval pathways and clues for reconstruction at recall.

In a previous study conducted under similar conditions (Gagné et al., Note 1), subjects were asked to state what made them think of the propositions that they recalled. For highly familiar passages, subjects frequently reported what appeared to be elaborations. For example, in explaining how she remembered the sentence "Smith visits his sisters every Christmas" one subject said, "It was the only holiday mentioned and I can always remember Christmas." During reading this subject may have created the elaboration that the passage referred to a holiday, and stored this elaboration along with the actual information contained in the passage. Recall of the elaboration then assisted in the retrieval of the passage proposition. By contrast, for the moderately familiar passages, Emporer Hollingshead, no subject reported similar elaborations of the kind "It was the only holiday mentioned and I can always remember Ramadan."

Our definition of familiarity confounds several types of familiarity that one could distinguish. These include familiarity with the vocabulary, familiarity based on personal experience, and familiarity based on general knowledge of the topic area. One cannot say from this study which type of familiarity is most critical for long-term recall. Future studies should be directed at this question. [Some data from a previous study

(Gagné et al., Note 1) suggest to us that vocabulary knowledge makes less of a contribution than other additional knowledge to the variance in long-term recall]. The definition of familiarity used here, however, has important practical advantages in that teachers can easily recall the quantity of ideas stimulated by a topic (our definition of familiarity) while it may be more difficult for them to recall the quality of ideas.

An alternative interpretation of the effect of familiarity is that the highly familiar passages were learned in a meaningful manner while the moderately familiar passages were learned by rote (Ausubel, 1968). Meaningful material is anchored to an ideational scaffolding making it easier to retrieve than rote material which is not so anchored. Our data are certainly consistent with this interpretation; however, the notion of ideational scaffolding is not as well defined as the notion of elaboration. Our passages were scaled on the number of elaborations (related ideas) generated by a norming group. The notion "elaborations" has a clear operational definition associated with it. In addition, the general conception of long-term memory as a network of propositions (including both input propositions and elaborations) has been validated by many independent investigators using a wide range of materials (Anderson, 1976; Collins & Loftus, 1975; Hayes-Roth & Thorndyke, 1979). The elaborative processing interpretation does not invalidate notions of meaningful learning, but it does refine them by suggesting operationally defineable mechanisms that account for meaningful learning.

That cohesion, defined in this experiment as the repetition of concepts across sentences, neither enhanced nor interfered with recall suggests that the repetition of concepts across sentences is not critical for effective retrieval of information. This nonsignificant finding is interesting in light of studies by Haviland and Clark (1974) that show a positive effect for cohesion on comprehension. The discrepancy in results is probably due to the different dependent measures. Whereas Haviland and Clark measured speed of comprehension, we measured amount of long-term recall.

There may well be conditions under which cohesion does enhance recall. Unfortunately, the definition of cohesion used here was somewhat restricted. A better definition may be Halliday and Hasan's (1976) which states that "Cohesion occurs when the interpretation of some element in discourse is dependent on that of another" (p. 4). When a reader interprets discourse, he or she is elaborating on it and hence creating alternate retrieval pathways and/or clues for reconstructive recall. Thus, it would be premature to conclude that cohesion doesn't influence retrieval processes. Better manipulations of cohesion are needed before such a conclusion can be reached.

In conclusion, the main positive findings of this study are that familiarity with the concepts involved in new information facilitates both speed of learning and amount of recall. The effect of familiarity on learning has, of course, been demonstrated many times. However, its *independent* effect on retrieval had not been demonstrated, to our knowledge, prior to these studies.

Educational Implications

The most direct implication of this work is that students will remember more new information in content area reading if they are already familiar with many of the concepts to which the new information pertains. Some procedures used in content areas, especially the mastery learning procedures, are based on the assumption that no matter how difficult it is for a student to learn something originally, once it is learned it will be remembered. The data here suggest that this belief is not well-founded.[2] Rather, if a student has trouble comprehending because of a lack of prior knowledge, that student will also have trouble remembering it later on.

Another implication is that teaching methods that stimulate an enriched encoding of textbook information should have long-term benefits. Such methods include a class discussion of key concepts in a passage prior to reading the passage (e.g., Langer, 1981), critical evaluation of the logic of a passage, asking inference questions after reading, and/or asking for familiar examples after reading. These and other methods should help readers to elaborate on new information and should, therefore, benefit their attempts at retrieval and reconstruction.

Reference Note

1. Gagné, E.D., Yarbrough, D.B., & Bell, M. S. Prior knowledge and the long-term recall of information. Paper presented at the American Educational Research Association Convention, Boston, 1980.

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Footnotes

1. Results from a previous study, in which telephone versus direct contact collection of recall protocols was included as a factor, showed no differences in recall due to using a telephone procedure.
2. Mastery learning may be an effective method for the retention of intellectual skills (procedural knowledge). Our question about it has to do only with its possible effects on retention of information (declarative knowledge).

Table 1

Passages Used in the Study

Highly Familiar Passages	
High Cohesion Form	Low Cohesion Form
Governor Smith Governor Smith has many hobbies. Smith's father was a jewelry storekeeper. Governor Smith has eight sisters. Stamp collecting is a special hobby for Governor Smith. Smith visits his sisters every Christmas. Smith's favorite sister likes jewelry very much.	Governor Smith Governor Smith has many dogs. Smith's father was a bakery storekeeper. Governor Smith has eight children. Stamp collecting is a special hobby for Governor Smith. Smith visits his sisters every Christmas. Smith's favorite sister likes jewelry very much.
Henry James Henry James wrote historical novels. Many novels described states of mind produced by human actions. The setting was often in old Europe. Portrait is one of James' novels. It discusses the states of mind produced by human actions. The main character in the novel is an American woman in Old Europe.	Henry James Henry James wrote historical novels. Many novels described special situations leading to strange endings. The setting was often in Northern England. Portrait is one of James' novels. It discusses the states of mind produced by human actions. The main character in the novel is an American woman in old Europe.

Table 1 (Contd.)

Moderately Familiar Passages	
High Cohesion Form	Low Cohesion Form
Emperor Hollingshead Emperor Hollingshead has abundant avocations. Hollingshead's sire was a travelling sonneteer. Emperor Hollingshead has eight siblings. Racquetball is a noteworthy avocation for Emperor Hollingshead. Hollingshead frequents his siblings very Ramadan. Hollingshead esteemed sibling appreciates sonnets most considerably.	Emperor Hollingshead Emperor Hollingshead has abundant Weimaraners. Hollingshead's sire was a travelling cooper. Emperor Hollingshead has eight descendants. Racquetball is a noteworth avocation for Emperor Hollingshead. Hollingshead frequents his siblings every Ramadan. Hollingshead's esteemed sibling appreciates sonnets most considerably.
Thomas Gray Thomas Gray created eloquent verse. Many verses enumerated truisms of the Divine romanticized with meditative bliss. The philosophy was often of common mortality. "Elegy" is typical of Gray's verse. It presents truisms of the Divine romanticized with meditative bliss. The subject matter of the verse is the universal dignity in common mortality.	Thomas Gray Thomas Gray created eloquent verse. Many poems enumerated concepts of the universe elaborated with essential courage. The philosophy was often of heartfelt action. "Elegy" is typical of Gray's verse. It presents tuisms of the Divine romanticized with meditative bliss. The subject matter of the verse is the universal dignity in common mortality.

Table 2

Propositional Text Used to Score Recall Protocols for the Last Three Sentences in the Passage Titled "Governor Smith"

Sentence Four
1. (Is A, Stamp-Collecting, Hobby)
2. (Special, Hobby)
3. (Governor Smith, Hobby)
Sentence Five
1. (Visits, Smith, Sister)
2. (His, Sister)
3. (Visits, Christmas)
4. (Every, Christmas)
Sentence Six
1. (Likes, Sister, Jewelry)
2. (Favorite, Sister)
3. (Smith's, Sister)
4. (Likes, Much)
5. (Much, Very)

Table 3

Means and Standard Deviations for Number of Correctly Recalled Propositions As A Function of Familiarity and Cohesion[a]

Cohesion	Familiarity			
	High		Moderate	
	M	s.d.	M	s.d.
High	4.47	2.80	.44	1.09
Low	5.53	3.38	.75	1.39

[a] Total possible propositions, averaged over the two passages was 13.

APPENDIX 4

Abstract

Two types of training in elaborative processing were compared. Awareness/practice training involved getting students to identify goals for which elaborative processing would help, to identify good elaborations, and to practice generating elaborations while studying. Practice Only involved practice in generating elaborations only. The Awareness/Practice group showed better delayed recall of material embedded in the training program. They also reported more use of elaborations in studying and recalling transfer passages, and greater one week recall of these passages. It was concluded that the training program was successful in teaching students when and how to elaborate and in getting this strategy to transfer to a new task performed seven days after training in which elaborative processing was not cued.

Training Seventh Graders to Elaborate

Elaboration, in its broadest sense, refers to the addition of information. In general, current uses of the term in the psychological literature are consistent with this broad definition, although various psychologists have specialized its use for the particular contexts in which they are interested. Torrance (19), for example, defines elaboration on the figural form of his test for creativity as the number of details people put in their drawings. Dansereau (1978) defines elaboration as (p. 15) "making links interesting and unusual through imagery, analogies, and humor," where links refer to links between bits of information. Somewhat more broadly, J. R. Anderson (1978) says that elaboration is the process whereby subjects (p. 378) "deposit in memory more than what they are overtly required to commit to memory." Our own use of the term is similar to Anderson's: We define elaboration as the learner's adding to that which is being learned. The product of elaboration (called an elaboration) may be an inference, an image, an example, or an analogy. It may be a summary, the result of a working out of a computation, or a play on words. The only constants across elaborations are (1) that they are generated by the learner, and (2) that they add information that was not explicit in the learning materials.

Elaboration has been shown to be a highly effective strategy for paired-associate learning (Rohwer & Ammon, 1971; Rohwer, 1980). More recently, elaboration has been shown to be useful in comprehension (Wittrock, 1974), retrieval (Gagné, Yarbrough, Bell, & Weidemann, Note 1), and transfer (Mayer, 1980). In fact, many of the factors that have been shown to positively influence comprehension can be interpreted as exerting their influence through the creation of elaborations (Reder & Anderson, 19). Elaboration is thought to exert its influence by creating a rich memory structure that speeds comprehension by providing context, facilitates retrieval by providing multiple retrieval pathways, and enhances transfer through the variety of associated contexts that can be accessed.

It appears that less competent learners are not aware of the power of elaboration. For example, Weinstein (1978) reports that (p. 53) "Army recruits with no high school experiences, or a GED equivalency diploma, report using rote repetition as their major learning strategy whereas second- and third-year undergraduate college students report meaningful elaboration and more active processing strategies." Younger students appear to behave like less competent older students. For example, on a questionnaire about study strategies given to seventh graders after they studied a passage, we found that these students were much more likely to use a rehearsal than an elaboration strategy. Thus, both younger and less competent learners seem to be relatively unskilled at elaborative processing.

Because elaborative processing is so generally effective and because younger learners appear to be relatively unskilled at elaborative processing, it should be useful to train students to use elaborative processing strategies. Thus, a major purpose of the study reported here was to develop and evaluate an elaboration training program for seventh graders.

In designing our training program we were influenced by several sources. The instructional design model of R. M. Gagné and Briggs (1974) based on R. M. Gagné's domains of and conditions for learning (1972) served as a general guide for classifying learning outcomes and for designing instructional support based on this classification. The work of Dansereau and his colleagues (Note 2) provided us with the insight that it is important to include process descriptions and feedback on processes within training. Finally, the work of Brown and her colleagues (cf. Brown, A. L., Campione, J. C., & Day, J. D., 1981) led us to conclude that awareness of the significance of the strategy, explicit knowledge of when and how to use the strategy, and training in monitoring the success of strategy application were all important aspects of training if the goal is to produce a generalizable strategy.

In fact, the second major purpose of our study was to test Brown's proposal that awareness is an important component of strategy training. We did this by having two groups, one that practiced making elaborations, and another that learned why, when, and how to use elaborations in addition to practicing making them. If awareness is important for strategy transfer, then only the second group should show transfer of elaborative processing to new situations.

METHOD

Training

Design

The design was a two group design with the groups being (1) Awareness/ Practice and (2) Practice Only. Both groups received practice in elaborating but only the Awareness/Practice group received instruction in the benefits of elaborating and when and how to elaborate.

Subjects

The subjects were all 44 seventh grade students at a private day school. Their average IQ score on the Otis-Lennon Mental Ability Test was 117 (range, 104-140). Their average percentile rank (national norms) on reading achievement, as measured by the Comprehensive Testing Program of the Educational Testing Bureau, was the 87th percentile. There were 23 males and 21 females; 43 caucasions and 1 black.

At the beginning of the school year, the students had been randomly assigned to one of two sections (22 students in each section). These sections had different homeroom teachers, otherwise had similar experiences throughout the day, moving to different classrooms for instruction in math, history, science, language arts, art, and music. Both sections had the same teacher in each subject and received the same assignments and tests.

Our training programs were integrated into the language arts curriculum. The Awareness/Practice training program was taught to one section for 10 consecutive school days and the Practice Only training program was taught to the other section for four consecutive school days, corresponding to the last four days of the Awareness/Practice program.

Although we administered the training programs to intact sections, we assumed that there were no systematic differences between the two sections because (1) the students had been randomly assigned to sections at the start of the school year, (2) the two sections had the same curriculum experiences and the same teachers, and (3) the average IQ and reading achievement test scores for the two sections were not significantly different.

Trainers

The four authors of this article were the trainers. Each day of training one of us served as the lead teacher and one as support teacher, with the roles varying over days and sections such that each section had each trainer in each role roughly equal numbers of times.

Training Objectives

Awareness/Practice. Training for this group involved bringing students to mastery on the following objectives, using R. M. Gagne's (1974) types of learning outcomes to classify objectives.

1. (Verbal information) Given a variety of cues, such as a fill-in-the-blank task, a why question, or a summary question, the student correctly fills in the blanks or provides answers that give the following information:

   (a) An elaboration is a thought that adds something to what you want to remember (the target).

   (b) When I want to remember something for several hours, days, weeks, or months, the best thing for me to do is think of some elaborations to the target (what I want to remember). Then, if I can't at first remember the target, I can try to remember the elaborations and they will help me remember the target.

   (c) The best kinds of elaborations are ones that add much information, organize the target, and/or are elaborations to the main idea.

   (d) When I want to remember something for a long time, I should think of elaborations that add much information, organize the target, and/or elaborate on the main idea.

   (e) The best time to elaborate is immediately after I have learned the target information.

   (f) When I am trying to recall something and I get stuck, I should think of some elaboration I made when I was studying and that should help me recall.

   (g) Elaborations are helpful in any subject (e.g., math or history) and for many types of information (e.g., a speech or a chapter in a book).

2. (Attitude) Given the choice of elaborating or not in a situation where long term memory is involved, the student will choose to elaborate.

3. (Skills)

(a) Given examples of elaborations and non-elaborations (e.g., daydreams or repetitions of target information), the student correctly identifies the elaborations.

(b) Given examples of situations requiring the use of memory, the student correctly distinguishes between those situations that require remembering something for longer than 10 minutes from those that require remembering something for less than 10 minutes.

(c) Given examples of different learning and memory goals, the student correctly identifies those goals for which elaboration would be useful.

(d) Given a situation in which the goal is a long term memory goal, the learner generates elaborations for target information.

(e) Given elaborations that provide more and less information about a topic, the learner correctly identifies those that provide more information.

(f) Asked to generate elaborations to a topic, the learner generates and classifies elaborations that add more and less information.

(g) Given elaborations that provide more and less organization of target information, the learner identifies those that provide more organization.

(g) Asked to generate elaborations to a topic, the learner generates and classifies elaborations that organize the target a lot or only a little.

(i) Given elaborations to the main idea of a passage or to a detail, the learner correctly distinguishes the two.

(j) Asked to generate elaborations to a passage, the learner generates and classifies elaborations to the main idea and to a detail.

(k) Asked to apply the RUE strategy (Do I want to remember this information? Do I understand it? Elaborate. Are my elaborations good?) to reading new passages, the learner does so.

(l) Asked to apply the REA strategy (Can I recall the target? If not, can I recall elaborations I made to the target? Have I recalled all?) to recalling previously studied passages, the learner does so.

Practice Only. The objectives for this group were analogous to the objectives 3d, f, h, j, k, and l for the Awareness/Practice group. The difference in these objectives for the two groups was that the Awareness/Practice group, having already learned what an elaborations is, were simply asked to generate elaborations for new passages, sentences, or lists while the Practice Only group was asked specific questions that stimulated elaborations. For example, following reading a passage about Superman, Awareness/Practice subjects were told to "write your elaborations" while the Practice Only group was asked to write their answers to the following questions: "Would you like to have superpowers? Which ones and why?" and "What would have happened if Superman had been found by crooks and not by the Kents?" Thus, both training groups practiced generating elaborations to the same number of practice items.

Insert Table 1 about here

Training Procedure

Table 1 shows the sequence of topics and activities covered by the two groups. In general, the procedure involved (1) the lead teacher giving new information or directions, (2) the students performing an activity in their workbooks, (3) the lead and support teacher circulating to help students while the activity was being performed, and (4) the lead teacher giving feedback to the group, usually by calling on individual students who were known to have performed correctly. This procedure was cycled through from three to six times during any given day. On the last two days of training, which involved mostly practice for both groups, feedback was not given after every activity so that students could proceed at their own pace through the practice activities. An example of the workbook exercises is shown in Table 2. This exercise was completed by the Awarness/Practice group after they received the information that an elaboration was a thought that the learner added to the target information.

Insert Table 2 about here

Practice Materials

Of the 32 items to which all subjects generated elaborations, 11 were words, 2 were word lists, 11 were sentences, and 8 were passages of 1 to 4 paragraphs in length. One-third of the items drew from textbook material that was about to be covered in the students' math, history, science, or language arts courses (e.g., adding negative numbers, an event in the civil war). The rest of the items covered topics of general interest (e.g., the Heimlich manuever, a shopping list) or were narratives (e.g., Superman).

Our purpose in using a wide variety of materials was to encourage later use of the elaboration strategy in a variety of situations.

Comparisons of the Awareness/Practice and Practice Only Groups

As the above discussion indicates, the items to which the Practice Only students generated elaborations were the same as the items to which the Awareness/Practice students generated elaborations. However, the nature of the stimulus conditions surrounding these materials was different for the two groups. Specifically, the stimulus conditions for generation of elaborations in the Awareness/Practice group were usually quite general (e.g., "Think of an elaboration for this paragraph"), whereas they were typically quite specific in the Practice Only group (e.g., "Tell me a picture that comes to your mind when you read this paragraph").

Another difference between the two groups was that the Awareness/Practice group had more objectives to meet. They distinguished situations in which elaborations were more or less helpful, and types of elaborations that were more or less helpful. They experienced and attended to the increased memory power associated with using elaborations. The Practice Only group neither made these distinctions nor was made aware of the utility of elaborations. If subjects in this latter group learned that elaborations were useful, it would be purely by induction.

In summary, the important differences between the two groups were (1) learning the conditions under which the elaboration strategy is beneficial, (2) learning the types of elaborations that are helpful, and (3) awareness of the utility of elaborations. If, in fact, self-awareness and monitoring skills are important for the acquisition of strategies (Brown, 19) then only the Awareness/Practice group should show improved memory perfromance.

Procedure

In instruction for the Practice/Awareness group, the lead teacher provided new information orally and on the blackboard and then the class answered workbook questions to demonstrate their understanding of the new information. Both the lead and support teachers circulated around the classroom while workbook exercises were being completed in order to give individual guidance and identify correct answers. Then, the lead teacher gave group feedback by asking a student who had been identified as having the correct answer to give the answer. Misunderstandings were also corrected at this time. This general cycle of instruction was repeated several times during each class period.

Throughout the 10 days, the focus of instruction moved from learning the components of the strategy (when and how to elaborate) to practicing the strategy on a variety of materials.

Instruction for the Practice Only group did not involve the provision of new information. Rather, the students were directed to read stimulus items including lists, sentences, and passages and answer elaboration questions about them. These were the same items used for practice by the Awareness/Practice group. After each item was studied several students shared their answers. The lead teacher accepted all answers and commented neutrally on the fact that different people had different answers.

Workbook Scores

For both groups, a check on attending behavior was made by examining each student's performance on daily workbook exercises. For the Practice Only group the check was simply whether or not the student had answered each question since there were no right or wrong answers.

For the Awareness/Practice group some items had correct answers and were scored for correctness while other items, that is the practice items, had no correct answer, and were simply scored for compliance with instructions. The total possible points for workbook items for this group was 187. Data from students whose scores were outliers below the mean score were not included in the data analyses because it was not clear that these students had paid attention.

Training-Embedded Recall Tests

Two tests of recall were embedded in the practice materials towards the end of training. These tests were conducted to see whether recall was greater in the Awareness/Practice gropu when they were directed to generate their own elaborations than in the Practice Only group when they were asked specific questions designed to stimulate elaborations. If Awareness/Practice group recall is better, this provides another rationale for training students to elaborate by showing that student-generated elaborations are better than teacher (workbook) provided elaborations.

Recall of a list. Both groups saw the same list of 15 countries and were told they would have to recall the list in a week. The Practice Only subjects answered the following two questions about the list:

1. If you formed an image of some continent on the world map, what countries from the above list would be in the image?

2. How would you summarize the above list?

The Awareness/Practice subjects were directed to apply the sequence of steps they had learned for the elaboration strategy. (This sequence was called RUE, for Remember, Understand, Elaborate). The first step involved asking (1) Do I want to remember this information?, and (2) Do I understand it? If the answer to these two questions was affirmative, then the next step was to generate elaborations. The last step was to evaluate the elaborations generated according to criteria already learned. This sequence was cued on the student's workbook sheet by the following cues typed underneath the list of countries:

1. Do I want to remember it?
2. Do I understand it?
3. Write your elaborations.

Are my elaborations good (meaningful, organized, to the main point)?

Three days later, all students were told to write down in their workbooks all the countries they could remember from the list they learned. In addition, the Awareness/Practice subjects were directed to use the sequence of steps they had learned for recalling information. This sequence involved asking "Can I recall the target information?" If the answer was no, then the next question was "Can I recall an elaboration?" And, finally, the question "Have I recalled all the target information?" was asked. This sequence was given the acronym REA for Recall, Elaborations, and All. The directions for recalling the countries for the Awareness/Practice subjects did not specifically state each step in the REA sequence. All they said was "Use the REA method to help you recall the list of countires you learned last week."

Recall of Superman passage. On the next to the last day of training both groups read a four paragraph passage about Superman as one of their workbook exercises. For the Practice Only group the directions read "Assume that you will have a test on the main ideas of the following story. Read the passage carefully, then turn the page and write the answers to the questions." The questions that followed were "Would you like to have

Superpowers? Which ones and why?" and "What would have happened if Superman had been found by crooks and not by the Kents?" For the Awareness/Practice group the directions read "Assume you will have a test on the main ideas of the following story. Apply the steps and questions of RUE to the story to help you learn it." Following the story an additional cue was provided that said "Write elaborations." Both groups performed these tasks at their own speed. Those who finished early went on to the next exercise in their workbooks.

The next day both groups were asked to recall the Superman story. The directions in the Practice Only workbooks read "You read and studied a passage about Superman. Write down everything you can from that passage below." The directions in the Awareness/Practice workbooks read "Using the REA method of recall write down everything you recall from the Superman story you read yesterday."

Recall protocols were compared to a textbase of the passage that contained 116 propositions (Turner & Green, 1980). Protocols were scored for correct propositions, and for a more generous score which included plausible inferences, and propositions with generalized arguments or relations as well as strictly correct propositions. (A generalized argument is a more general term than the term used in the text for a topic--for example, "child" instead of "boy". A generalized argument is a more general term than the term used in the text for a relation--for example, "made" instead of "sewed".)

Transfer

Subjects

Sixteen students were randomly selected from each seventh grade section for participation in the transfer study. Because the transfer tests were administered individually, time and space limitations necessitated our testing only 16 of the 22 students from each group.

Testers

The transfer tasks were administered by graduate students who had been trained to administer the tasks. Also, two of the authors administered the transfer tasks. However, only three subjects in the Awareness/Practice group and four subjects in the Practice Only group received their transfer tasks from one of the trainers that they knew from training. Presumably, having different people involved in giving the transfer task increased the differences between the training and transfer situations.

Materials

The transfer passages were four expository paragraphs the attributes of which have been described in detail elsewhere (Gagne, Bell, Yarbrough, & Weidemann, 1981). They comprised two pairs that were matched on syntax while varying on familiarity of the topic (see Gagne, et al., 1981, for the text of the passages and familiarity norms). The titles of the passages were Cakes, Alloys, Piano, and Fire. Each subject learned one passage from each pair, one at each level of familiarity. Half the subjects in each group learned each passage, and passage familiarity was counterbalanced across order and across treatment groups.

Procedures for Transfer Task

The transfer task occurred in two phases. Phase 1, during which students studied two new passages and reported their study strategies for the second passage, occurred six to eight days after the completion of training. Phase 2, during which students recalled these new passages and reported their recall strategies for the first passage, occurred seven days after Phase 1. Phase 2 occurred during the last week of school.

Phase 1

During this phase, each subject was given two passages to learn to a criterion of 85% correct propositions using Kintsch's (1974) definition of propositions as elaborated by Turner and Greene (1980). One passage was moderately familiar and one highly familiar, with order of familiarity counterbalanced over the two groups. Learning proceeded by a study-test procedure that has been described elsewhere (Gagne, Weidemann, Bell, & Yarbrough, in press), but essentially it involved giving the subjects about one minute to study each passage, then removing it and having him or her say out loud all that could be recalled from thepassage, then repeating these two steps until the subject recalled 85% of the passage propositions. The purpose of bringing students to criterion was to better isolate a study period from a period of original learning. That is, we wanted to examine the strategies used by students after new material was fairly well learned when the goal was to improve the material's retrievability.

After the student reached criterion on the first passage, he or she was told "I will be back in a week or so. At that time I will ask you to recall the passage you have learned. Now, I am going to give you five minutes to study the passage." In addition, they were told that they could not use pens during the five minute study period, nor should they write down the passage after leaving the room.

Following the five minute study period, each subject was asked an open-ended question about study strategies followed by three direct questions about elaboration strategies (e.g., "Did you form a picture in your mind of part or all of the passage?") and three direct questions about rehearsal strategies ("Did you repeat all or part of the passage over and over?"). The direct questions about elaboration and rehearsal strategies used during study and the sequence in which they were asked are shown in Table 3.

Insert Table 3 about here

The open-ended question was "What did you think of or do during the past five minutes to study the paragraph?" Following the answer, the tester asked, if appropriate, "Can you tell me more about that?". Depending upon what strategy the subject reported using, a series of questions were then asked to get a more detailed picture of the strategy. For example, if a subject said that he repeated the passage, the tester asked "Did you repeat the entire passage?" and "How many times?". If the subject said that she/he elaborated on the passage, the tester asked "Can you give me an example of an elaboration you thought of?" and "Did you think of any other elaborations?"

The format of this questionnaire was designed to minimize three sources of invalidity in retrospective reports (Ericsson & Simon, 1980). First, by asking about a recent event, memory problems were reduced. Second, by asking about one specific event, inaccurate generalizations were avoided. Finally, by keeping questions open-ended, the possibility of cueing a response was avoided. We only mentioned an activity (e.g., repetition, elaboration) after it was mentioned by the subject.

Phase 2

One-week later students wrote down what they recalled from both the passages they had studied during Phase 1. After recall of the first passage, the tester pointed to each sentence the student had written down and said "What was going through your mind just before you thought of this sentence?" The student's answers were recorded and later classified as either elaborations or non-elaborations.

Next, the tester asked about the student's recall strategies, following a format similar to what was used for asking about study strategies. That is, the tester first asked an open-ended question with follow-up probes and then asked three direct questions each about cues based on rehearsal (e.g., "Did you remember sentences that you repeated over and over when you were studying?") and cues based on elaboration (e.g., "Did you use a picture you made while you were studying last week to help you recall today?")

The open-ended question was "What did you do just now to assist you in recalling parts of the passage?" The wording of this question was chosen to avoid cueing a rotely learned response. During training the words "help" and "remember" were used rather than "assist" and "recall." Thus, if a student had rotely memorized that "forming elaborations helps me remember," this would be unlikely to be cued by the above question. The general question was followed with probes, with the exact nature of the probe depending upon what the student's answer was to the general question. For example, if the student said "I remembered my elaborations and then used them to remember the passage," the tester would ask "Can you give me an example of that?"

Following the questions about strategies used to retrieve information, the experimenter asked whether the student (1) rehearsed the passage during the one week interval, and if so, how much; (2) whether he or she wrote down the passage and used this to study; and (3) whether he or she got help from a fellow student before coming to recall the passage. These questions were asked in order to check for possible group differences in retention interval strategies.

Results

The probability values for almost all of the comparisons between groups are one-tailed values because our prediction was that the Awareness/Practice group would be better than the Practice Only group. The exceptions to this were the scores derived from direct questions about rehearsal strategies. We did not expect group differences on these measures because rehearsal was not the objective of training. Therefore, the probability values for the rehearsal scores are two-tailed.

Workbook Scores

The total possible score across 10 workbooks for the Awareness/Practice group was 187. The scores obtained ranged from 107 to 174 with a mean of 151.23 and a standard deviation of 15.19. The average score was 81% of the best possible score.

Two students' scores were outliers on the low end of the score distribution, both being more than 1.5 standard deviations below the mean. One of these students was absent on half of the training days and the other did not pay attention. The data for these two students was dropped from the analyses.

All students in the Practice Only group completed most of the workbook exercises (the exceptions were two students who were absent for one of the training days). Therefore, none of the data from this group was dropped due to lack of attending to the treatment.

Training-Embedded Recall Tests

List of countries. The total possible for this measure was 15. The means and standard deviations for number of countries recalled three days after learning are shown in Table 4. A t-test of the difference between means was significant, $\underline{t}$ (39) = 7.38, $\underline{p} < .0005$. As expected, the performance of the Awareness/Practice group (M = 11.11) was superior to the performance of the Practice Only group (M = 4.32).

Insert Table 4 about here

Superman passage. One day recall of the Superman passage was scored with both a strict criterion (textbase propositions only) and a generous criterion (textbase propositions plus plausible inferences and elaborations plus textbase propositions with generalized relations or arguments). The patterns for these two scores was quite similar as can be seen in Table 5.

Insert Table 5 about here

A t-test of the difference between means using the strict criterion was marginally significant, $\underline{t}$ (37) = 1.34, $\underline{p} < .10$. Using the generous criterion, the t-test was significant, $\underline{t}$ (37) = 1.68, $\underline{p} < .05$.

Study Strategies Used on the Transfer Task

The means and standard deviations for reported strategies during the study period on the transfer task are shown in Table 5. The open-ended measure of generation of elaborations revealed a significant difference in favor of the Awareness/Practice group, t (27) = 2.54, $p < .025$. The direct questions about elaboration also showed an average difference in favor of the Awareness/Practice group, however, this difference was not significant. The direct questions about rehearsal showed an average difference in favor of the Practice Only group, but this was not significant.

The means and standard deviations for recall strategies are also shown in Table 5. The means for both the open-ended and direct questions about use of elaborations are greater for the Awareness/Practice group than for the Practice Only group: Ms = 1.50 and .93, respectively, for the open-ended question and 1.14 and .57, respectively, for the direct questions. The differences between means were significant for both the open-ended and direct questions: t (27) = 1.67, $p < .05$ and t (26_ = 2.31, $p < .025$, respectively. The difference between groups on use of prior rehearsal to cue recall was not significant.

Retention interval behavior. The students were questioned about rehearsal during the retention interval, writing passages down and studying them during the retention interval, and asking another student to help them recall a passage during the retention interval. Almost no students wrote down the passages they had learned or asked for help. The data from the one student (in the Practice Only group) who did write down the passages was not used in the analyses.

There was a fairly low amount of retention interval rehearsal in both groups (Ms = 1.86 and 1.40 for the Awareness/Practice and Practice Only groups, respectively) and the difference between groups on the average amount of retention interval rehearsal was not significant, t (27) = .52.

Thus, it appeared that the two groups were equivalent on retention interval activities. Since they were also equivalent on amount of original learning of the transfer passages, any differences in recall could be attributed to the study and recall strategies.

Recall of transfer passages. To obtain the most reliable estimate of recall, each student's recall from each passage was added together. (This was done after preliminary analyses showed no interaction of Training Group and Passage Type in influencing recall, F (1,27) = .10). The mean recall of the Awareness/Practice group was 24.85 (s.d. = 12.81) and the mean recall of the Practice Only group was 18.27 (s.d. = 10.57). This difference was marginally significant, t (27) = 1.46, $p < .10$. Since the overall level of recall was only 21% of all possible propositions a "floor effect" may account for the marginal level of significance.

Reports of Elaborations that Cued Recall

For each student, we computed the proportion of correct propositions for which an elaboration provided a cue. The average proposition for the Awareness/Practice group was 55.00% while it was 25.60% for the Practice Only group (s.d.s = 38.41 and 31.93, respectively). The groups differed significantly, t (27) = 2.25, $p < .025$.

Discussion

The purposes of this study were (1) to evaluate a program designed to train students to elaborate on information they want to remember, and (2) to test the hypothesis that if transfer is a goal, then "awareness" is an important aspect of strategy training programs. Each of these purposes will be discussed in turn.

Evaluation of the Program

Learning of training objectives. The Awareness/Practice group had an average learning score of 81% correct on workbook items. These items included the ability to verbalize when, why, and how to elaborate, the ability to identify new situations in which elaborating would be helpful, the ability to distinguish elaborations from repetitions and irrelevant daydreams, the ability to distinguish good from less good elaborations, and the ability to generate elaborations. The items also included practice in reading passages, deciding if one should elaborate, and then elaborating and in using elaborations to cue recall of target information. The overall high score on these workbook items suggests that the training program successfully taught the objectives.

It might be the case, however, that the students would have performed just as well on workbook items without training. Unfortunately, there were not enough students in the school to have the no treatment control group needed to rule out this alternative. One bit of evidence that suggests that the training program rather than prior knowledge accounts for the high performance scores is the students' self reports when asked to write down what they had learned during training. Almost all of the students said that they had learned how to elaborate and that they expected to use this strategy in the future. If the students had already known the information in the training program, we doubt that they would have said that they learned to elaborate.

Long-term recall. On two tests of delayed recall embedded in the training programs, the Awareness/Practice group outperformed the Practice Only group. For these two tests the Awareness/Practice group was directed to elaborate while the Practice Only group was given questions that stimulated elaborative processing. The results suggest that self-generated elaborations have greater benefits for long-term recall than do teacher-stimulated elaborations and thus underscore the importance of attempting to teach elaborative processing strategies.

The Importance of Awareness for Transfer

All of the results related to elaborative processing of the transfer passages favored the Awareness/Practice group over the Practice Only group. The Awareness/Practice group reported generating more elaborations during a study period and using these to aid their recall of passage propositions one-week later. In addition, the amount of text propositions recalled was greater for the Awareness/Practice group than for the Practice Only group.

Although the difference between groups on recall of propositions was substantial (the Awareness/Practice group recalled 27% more than the Practice Only group), it was only marginally significant. Unfortunately, during the days that the recall tests were administered the students were eager to return to exciting end-of-school activities, (such as a school play) that were going on in their regular classes. Thus, some students did not persist in attempts to retrieve information. Given this low motivation, the fact that a difference showed up at all suggests that the effect is real and that it should show up more strongly under more favorable conditions.

Conclusion

The data are encouraging for the success of strategy training programs, but not conclusive. Some additional studies of the importance of knowing when, why, and how to perform a strategy are needed, but it appears that blind practice is not as useful in producing strategies that transfer to new situations as is practice combined with awareness.

Table 1

Lesson Topics and Sequence for the Awareness/Practice and Practice Only Groups

Topic		Date
Awareness/Practice	Practice Only	
What is an elaboration?		4/28/81
Why use elaborations?		4/29/81
Good elaborations generate much information		4/30/81 & 5/4/81
Good elaborations organize information		5/5/81 & 5/6/81
Good elaborations add to main ideas	Practice Session 1	5/7/81
When to elaborate		5/8/81
What to do when trying to recall	Practice Session 2	5/8/81
Practice in deciding whether to elaborate, elaborating, and recalling elaborations	Practice Session 3 Practice Session 4	5/11/81 5/12/81

Table 2

A Sample Workbook Page (Awareness/Practice Group)

Here are six examples of things that are elaborations and things that are not elaborations. Read each example. In the blank of the left of each example, write E if you think that the example is an elaboration. If you think the example is not an elaboration, write NE in the blank.

E = Elaboration

NE = Not an Elaboration

1. ____ A student reads "Columbus discovered America in 1492," and decides she wants to remember it. She repeats in her head "Columbus discovered America in 1492."
2. ____ John reads "Columbus was a Spaniard. He sailed to America in 1492." He wants to remember this information, so he thinks "Columbus most likely sailed West to America because the shortest way to get to America from Spain is to go West."
3. ____ Jack reads "Columbus discovered America in 1492. Columbus was a Spaniard." He thinks "I wonder what's for lunch?"
4. ____ Susan hears her arithmetic teacher say "To divide fractions, invert the divisor and multiply." Then the teacher says "Rember the divisor is what you divide by."
5. ____ Sally hears her arithmetic teacher say, "To divide fractions, invert the divisor and multiply." and thinks "That's another rule for working with fractions. In the multiplication of fractions, you don't invert the divisor, you must multiply."
6. ____ A student hears his science teacher say, "Molecules are farther apart in gases than in liquids, so gases are lighter." The student thinks "That is like loosely woven cloth is lighter than tightly woven cloth of the same material."

Table 3

The Content and Sequence of Direct Questions Asked About Study and Recall Strategies

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Study Strategies

While you were studying the passage just now:

1. Did you repeat sentences over and over again?
2. Did you try to picture one or more of the sentences or ideas in your mind's eye? (If yes) What was the picture?
3. Did you count the number of sentences and keep trying to recall until you remembered all the sentences? (If yes) How many sentences were there?
4. Did you think of a comparison between something in the paragraph and something you already know? (If yes) What was the comparison?
5. Did you break the paragraph into parts and try to work on one part at a time? (If yes) What were the parts?
6. Did you think of other things the ideas in the paragraph reminded you of? (If yes) Give me an example.

Recall Strategies

While you were recalling the passage just now:

1. Did you think of a picture that you had thought of when you were studying the passage last week? (If yes) What was the picture?
2. Did you think of the order of the sentences and try to fill in the ones that were missing? (If yes) Which ones were missing?
3. Did you think of some thought you had when you were studying that related to the passage? (If yes) What was the thought?
4. Did you think of what you had repeated over and over during study and try to remember the sentence that was easiest to repeat first?
5. Did you think of comparisons you had made during study between the passage ideas and the other ideas? (If yes) What were the comparisons?
6. Did you think of certain parts of the passage and try to recall those parts as units? (If yes) Why did they go together?

Table 4

Training Embedded Tests of Delayed Recall

	Awareness/Practice		Practice Only		t-value
	M	s.d.	M	s.d.	
List of 15 countries	11.11	2.38	4.32	3.34	7.38***
Superman passage propositions	25.74	8.69	21.20	8.20	1.68*

*$p < .05$

***$p < .01$

Table 5

Retrospective Reports of Use of Elaborations During Study and Recall of Transfer Passages

	Awareness/Practice		Practice Only		t-value
	M	s.d.	M	s.d.	
Elaboration during study: Open-ended question	2.57	.65	1.93	.70	2.54**
Elaboration during study: Direct questions	1.43	1.02	1.00	.93	1.18
Rehearsal during study: Direct questions	1.79	.89	2.20	.77	-1.34
Use of elaborations at recall: Open-ended question	1.50	.94	.93	.88	1.67*
Use of elaborations at recall: Direct questions	1.14	.66	.57	.65	2.31**
Use of rehearsals at recall: Direct questions	1.50	.85	1.43	.94	.21

*$p < .050$

**$p < .025$